WBS 9.2.1.2
QA: N/A

Civilian Radioactive Waste Management System
Management & Operating Contractor

Report to Update Total System Life Cycle Cost Estimate for Site Recommendation/License Application

TDR-CRW-SE-000001 REV 01

December 1999

Prepared for:

U.S. Department of Energy
Office of Civilian Radioactive Waste Management
1000 Independence Avenue, SW
Washington, DC 20585

Prepared by:

TRW Environmental Safety Systems, Inc.
600 Maryland Ave. S.W.
Suite 695
Washington, DC 20024

Under Contract Number
DE-AC08-91RW00134

DISCLAIMER

WBS 9.2.1.2
QA: N/A

Civilian Radioactive Waste Management System
Management & Operating Contractor

Report to Update
Total System Life Cycle Cost
Estimate for
Site Recommendation/License Application
TDR-CRW-SE-000001 REV 01

December 1999

Prepared by:

________________________ ____________

S. M. Burney Date
Systems Analysis/Cost Department

Checked by:

________________________ ____________

S. G. Gillespie Date
System Analysis/Cost Department

Approved by:

________________________ ____________

L. L. Meyer, Manager Date
System Analysis/Cost Department

Approved by:

________________________ ____________

R. C. Wagner, Manager Date
Systems Engineering and Integration Office

Approved by:

________________________ ____________

C. A. Heath, Assistant General Manager Date
Waste Management and Integration

CHANGE HISTORY

Revision Number	Interim Change Number	Effective Date	Description and Reason for Change
00	00	09/99	Initial Issue.
01	00	12/99	Incorporates DOE comments to Rev 00. Editorial changes made to clarify text. Cost data from 1999 through 2010 changed to reflect actual 1999 costs, the 2000 budget appropriation, and updated RIMS projections from 2001 through 2010.

CONTENTS

Page

CONTENTS (Continued)

Page

FIGURES

Page

INTENTIONALLY LEFT BLANK

TABLES

Page

TABLES (Continued)

Page

ACRONYMS

ACR	Annual Capacity Report
APR	Acceptance Priority Ranking
BCP	Baseline Change Proposal
BWR	Boiling Water Reactor
CR	Change Request
CRD	CRWMS Requirements Document
CRWMS	Civilian Radioactive Waste Management System
D&E	Development and Evaluation
DOE	U.S. Department of Energy
DP	Dual-Purpose
EDA	Enhanced Design Alternative
HLW	High-Level Waste
INEEL	Idaho National Engineering and Environmental Laboratory
IPWF	Immobilized Plutonium Waste Form
LA	License Application
LADS	License Application Design Selection
LWT	Legal Weight Truck
MGR	Monitored Geologic Repository
MPC	Multi-Purpose Canister
MRS	Monitored Retrievable Storage
MOX	Mixed-Oxide
MTHM	Metric Ton(s) of Heavy Metal
NRC	U.S. Nuclear Regulatory Commission
NWF	Nuclear Waste Fund
NWN	Nuclear Waste Negotiator
NWPA	Nuclear Waste Policy Act, as amended
NWTRB	Nuclear Waste Technical Review Board
OCRWM	Office of Civilian Radioactive Waste Management
OMB	Office of Management and Budget
PC	Performance Confirmation
PETT	Payment-Equal- To-Taxes
PI&I	Program Integration and Institutional
PM&I	Program Management and Integration

ACRONYMS (Continued)

PWR	Pressurized Water Reactor
QA	Quality Assurance
RSC	Regional Servicing Contractor
RIMS	Regulatory, Infrastructure and Management Support
SNF	Spent Nuclear Fuel
SP	Single-Purpose
SR	Site Recommendation
SRS	Savannah River Site
TSLCC	Total System Life Cycle Cost
VA	Viability Assessment
WA	Waste Acceptance
WAST	Waste Acceptance, Storage and Transportation
WHB	Waste Handling Building
WP	Waste Package
WV	West Valley
YOE	Year of Expenditure

1. INTRODUCTION AND SUMMARY

1.1 PURPOSE AND SCOPE

This report documents an analysis of the Total System Life Cycle Cost (TSLCC) for one concept for the Civilian Radioactive Waste Management System (CRWMS). This analysis is consistent with the design basis of the selected alternative, Enhanced Design Alternative II (EDA II), evaluated in the *License Application Design Selection Report* (CRWMS M&O 1999c). Two cost scenarios are presented within this document to address open policy questions relating to the implementation of the EDA II design from the License Applications Design Selection (LADS) study. Both cases represent the total system cost for the EDA II design described in the LADS Report, modified for emplacing all planned waste quantities in *the Civilian Radioactive Waste Management System Requirements Document*. Rev. 05 (DOE 1999a). Case 1 assumes that closure and decommissioning activities can begin 50 years after the beginning of waste emplacement. Subsequent to the publication of the LADS Report (CRWMS M&O 1999c), discussions with the Nuclear Waste Technical Review Board (NWTRB) led to the consideration of keeping the repository open and ventilated for an additional 75 years. Case 2 represents the contingency of beginning closure and decommissioning activities 125 years after the beginning of waste emplacement, when it is expected that the temperature of the emplacement drift walls will remain below the boiling point of water.

This TSLCC updates the previous document *Analysis of the Total System Life Cycle Cost of the Civilian Radioactive Waste Management Program* (DOE 1998a). The major difference between these documents is the inclusion of EDA II design elements. The 1998 TSLCC was based on the design presented in the *Viability Assessment of a Repository at Yucca Mountain* (DOE 1998b). This TSLCC update is based on approved program design and direction current at the end of fiscal year (FY) 1999. When new program design information becomes available and is approved, this TSLCC estimate will be updated with a revision if there is a significant cost impact to the program.

Changes to the technical work scope, cost and schedule baselines, and selected management documents are executed via baseline change proposals (BCPs) or change requests (CRs). Both methods for change implement processes that support configuration control, and ensure integration, accountability, and traceability of decisions through the standardization of required information. The OCRWM *Program Baseline Change Control Procedure* (DOE 1997), and the *Integrated Planning, Change Request Preparation, and Baseline Change Implementation* (YAP-30.61) procedure are used to establish the responsibilities and processes for approving initial issues of and changes to the CRWMS.

This TSLCC estimate aids in financial planning, provides policy makers information for determining the course of the program, and is an input to a subsequent report on the adequacy of the one mill ($0.001) per kilowatt-hour fee charged on generators of commercial spent nuclear fuel (SNF). Since these estimates are for a system that spans an additional 70 to 145 years into the future, the concept costed should be viewed as representative of the system that will ultimately be developed.

The TSLCC estimate is based on acceptance and disposal of approximately 86,300 metric tons of heavy metal (MTHM) of commercial SNF, including mixed oxide (MOX) fuel. The estimate is also based on 2,570 MTHM of government-managed SNF, including naval SNF, and approximately 20,000 canisters of vitrified high-level waste (HLW), including some canisters containing immobilized plutonium waste forms (IPWF) contained in HLW glass. The estimate of commercial SNF assumes existing nuclear power reactors operate for their planned service life under current Nuclear Regulatory Commission (NRC) licenses. While little additional generation of HLW is expected at U.S. Department of Energy (DOE) sites in the future, quantities of HLW canisters may vary due to uncertainties in the planned processing and vitrification of the wastes.

The DOE is aware that existing law prohibits emplacement in the first repository of a quantity of spent fuel containing in excess of 70,000 MTHM, until such time as a second repository is in operation. However, current cost information, designs, or authorization for a second repository do not exist. Therefore, consistent with the 1998 TSLCC, a one-repository system without interim storage, has been assumed. Yucca Mountain is assumed to be the location for the repository since it is the only location that the DOE is authorized to characterize. This, however, does not constitute a pre-decision on the determination of Yucca Mountain as an acceptable site for the repository.

This TSLCC estimate should not be interpreted as a final estimate. Numerous assumptions were required with respect to waste management system design and operations where decisions have not yet been made. These assumptions are critical to the resulting cost estimate, and any changes in assumptions could influence the resulting estimate. Assumptions used in this analysis are for cost purposes, and should not be interpreted as final Office of the Civilian Radioactive Waste Management (OCRWM) or DOE policy.

Alternative designs and approaches for implementing the repository system have been and will continue to be analyzed. These analyses have shown that there are various ways for the program to proceed on schedule with various cash flow profiles, including lower annual funding requirements for the near-term years. Alternative implementation options include: early acceptance of waste; varying receipt rates; modular construction of the surface and underground repository facilities; varying the amount of spent fuel in lag storage; and using an approach to transportation with lower initial capital investment than the rail branch line to the Yucca Mountain site. Although these options can lower near-term repository cash flow profiles, they generally increase the TSLCC and vary costs to utilities for storage at their sites, depending on the rates of acceptance at the repository.

This TSLCC analysis is organized as follows:

Section 1. INTRODUCTION AND SUMMARY: This section introduces the reader to the overall purpose and scope of this analysis, and summarizes the results and conclusions.

Section 2. SYSTEM DESIGN: This section provides a description of the reference design, including an explanation of design differences between EDA II and the Viability Assessment (VA).

Section 3. MONITORED GEOLOGIC REPOSITORY: This section discusses the Monitored Geologic Repository (MGR) scope, assumptions, and costs included for each of six phases of the system life cycle.

Section 4. WASTE ACCEPTANCE, STORAGE AND TRANSPORTATION: This section discusses the Waste Acceptance, Storage and Transportation (WAST) scope, assumptions, and costs included for each of three phases, and for the construction of the Nevada rail.

Section 5. PROGRAM INTEGRATION: This section discusses Program Integration scope, assumptions and costs associated with this activity.

Section 6. INSTITUTIONAL: This section discusses Institutional scope, assumptions, and costs associated with this activity. It also provides a description of Payment-Equal-to-Taxes (PETT), Benefits, 180(c) grants, and financial assistance.

Section 7. COST SHARE ALLOCATION: This section presents the cost share allocations for life cycle costs for civilian and government-managed nuclear material, and West Valley (WV) HLW programs.

Section 8. REFERENCES: This section contains a list of references used throughout this document.

Appendix A. 1999 TOTAL SYSTEM LIFE CYCLE COST ESTIMATE SUMMARY: This section provides a summary of the 1999 TSLCC estimate by major cost categories, with breakouts of historical and future costs.

Appendix B. COMPARISON WITH 1998 TOTAL SYSTEM LIFE CYCLE COST: This section contains tables and text comparing the 1998 TSLCC (DOE 1998a) and the results of this analysis.

1.2 SUMMARY OF RESULTS AND CONCLUSIONS

Our national strategy maintains a clear focus on the long-term objective of waste disposal in a geologic repository. The scientific study of Yucca Mountain indicates that a repository can be designed and built at a site that would safely isolate SNF and radioactive HLW, and protect the public and the environment for tens of thousands of years.

The total estimated future cost to complete the program is $43.9 Billion from 2000 through closure and decommissioning in 2069 for Case 1, and $49.2 Billion for closure and decommissioning in 2144 for Case 2. A total of $6.3 Billion was spent on the total program through FY 1999 in year-of-expenditure (YOE) dollars. Table 1 provides a summary of the major CRWMS cost categories. The program is assumed to continue from its inception in 1983 through closure and decommissioning of the repository in 2069 for Case 1, and in 2144 for Case 2. An annual breakout of costs is provided in Appendix A.

Table 1. Summary of Results (in Millions of 1999$)

Cost Element	Historical Costs (1983-1999)	Case 1 Future Costs (2000-2069)	Case 2 Future Costs (2000-2144)
Monitored Geologic Repository	5,340	32,130	36,590
Waste Acceptance, Storage & Transportation	490	5,140	5,140
Nevada Transportation	0	790	790
Program Integration	1,590	2,130	2,610
Institutional	230	3,730	4,110
Total	**7,650**	**43,920**	**49,240**

NOTE: Historical costs total $6.3 Billion YOE.

1.3 CHANGE CONTROL

The 1999 TSLCC documents the design changes and subsequent cost changes that have occurred since the publication of the 1998 TSLCC (DOE 1998a). These design changes follow either the established baseline change control procedure or change request procedure that culminates in the approval of a BCP or CR, respectively. Table 2 is a listing of the BCPs (CRWMS M&O 1999d) and CRs (DOE 1999d) that have been developed since the publication of the 1998 TSLCC in December 1998, and that have been used as a basis for this TSLCC estimate.

Table 2. BCPs and CRs Since December 1998

No.	Approved Description
Approved Baseline Change Proposals	
BCP-00-00-001	Issuance of the Civilian Radioactive Waste Management System Requirements Document (CRD), Rev. 5, and approval to incorporate associated changes into the Waste Acceptance Requirements Document (WA-SRD), Rev. 3
BCP-00-99-0002	Approval of the integrated Interface Control Document (ICD)
BCP-00-99-0003	Control of reference information for the Office of Civilian Radioactive Waste Management (OCRWM) Program life cycle
BCP-00-99-0004	Issue Document Change Notice (DCN) 01 to incorporate interim Regulatory Guidance into the Civilian Radioactive Waste Management System Requirements Document (CRD), Rev. 5
BCP-00-99-0006	Issue Document Change Notice (DCN) to the Civilian Radioactive Waste Management System Requirements Document (CRD), Rev. 5, to add the requirement to provide solar power for the Subsurface Emplacement Ventilation System
BCP-00-99-0007	Issue Document Change Notice (DCN) to the Civilian Radioactive Waste Management Systems Requirement Document (CRD), Rev. 5, to change the preclosure period to 50 years after the start of initial waste emplacement
BCP-00-99-0008	Issue/baseline Revision 3 of the Office of Civilian Radioactive Waste Management (OCRWM) Program Work Breakdown Structure (WBS) and Dictionary
BCP-00-99-0009	Incorporate License Application Design Selection (LADS) Enhanced Design Alternative (EDA) II into the YMSCO Project Baseline
BCP-03-99-0001	Issue/baseline Revision 3 of the Waste Acceptance System Requirements Document (WA-SRD)

Table 2. BCPs and CRs Since December 1998 (Continued)

No.	Approved Description
Approved Baseline Change Proposals	
BCP-03-99-0002	Issue/baseline Revision 4 of the Office of Civilian Radioactive Waste Management (OCRWM) Waste Acceptance, Storage and Transportation (WAST) Project Work Breakdown Structure (WBS) and Dictionary
BCP-03-99-0003	Issue/baseline Revision 5 of the Office of Civilian Radioactive Waste Management (OCRWM) Waste Acceptance, Storage and Transportation (WAST) Project Cost and Schedule Baseline
Approved YMP Change Requests	
CR 2000/001	Revision to the Project Cost & Schedule Baseline Document to update planning for FY00-FY03 in YMP Multiyear Cost & Schedule Baseline

1.4 PROGRAM ASSUMPTIONS

The program level assumptions have not changed significantly since the 1998 TSLCC. The change to the EDA II design basis is a change to the MGR assumptions. The key differences in program level assumptions between the 1998 TSLCC Report (DOE 1998a) and this report are as follows:

1. Costs will be in constant FY 1999 dollars. New escalation rates based on a 1999 cost escalation report (CRWMS M&O 1999a) will be used.

2. The repository life cycle for Case 1 ends in 2069, assuming closure and decommissioning activities begin 50 years after the start of emplacement. Case 2 assumes closure and decommissioning activities begin 125 years after the start of emplacement, with the life cycle ending in 2144.

3. The assumed quantity of waste packages decreased from 15,706 to 15,454 due to blending hot fuel with cold fuel. It is assumed that blending will reduce the quantity of small pressurized water reactor (PWR) waste packages.

4. The MGR monitoring operations time phases changed from 2041 – 2110 to:

   a. Case 1 2041 – 2060
   b. Case 2 2041 – 2135

5. The MGR closure and decommissioning time phases changed from 2110 – 2116 to:

   a. Case 1 2060 – 2069
   b. Case 2 2135 – 2144

1.5 COSTING APPROACH

The cost estimates make assumptions regarding technical and policy decisions; some will not be made until after the Secretary of Energy issues a site recommendation (SR) report to the President in 2001. The schedule assumes a license application (LA) to the NRC in 2002, NRC authorization for construction approval in 2005, followed by NRC approval to receive and possess waste prior to the start of emplacement in 2010.

All future cost estimates are presented in constant 1999 dollars for ease of comparison and to eliminate the effects of inflation for a program with a duration of 70 to 145 years. Historical costs are noted in YOE dollars, and are escalated to 1999 dollars, using economic escalation indices for DOE construction projects to put all funds in constant year dollars (CRWMS M&O 1999a). This cost estimate does not include “take title” costs. Future cost estimates are rounded to the nearest $10 Million for costs greater than $100 Million.

2. SYSTEM DESIGN

During the preparation of the VA (DOE 1998b), the DOE directed the Management and Operating Contractor (M&O) for the Civilian Radioactive Waste Management Program to conduct a formal study of alternative design concepts for a potential geologic repository for SNF and radioactive HLW at Yucca Mountain, Nevada (Dyer 1998). The study, called the License Application Design Selection project, was initiated in July 1998, and resulted in the development and submission of the report in April 1999 and Revision 1 in May 1999 (CRWMS M&O 1999c). The focus of this study was on the engineered aspects of a potential repository that would complement the natural system of the Yucca Mountain site. The final study report evaluated five EDAs that addressed a range of thermal management strategies and incorporated many design features evaluated in the initial stages of the study. The LADS addresses comments by the Nuclear Waste Technical Review Board (NWTRB) to study alternatives to the repository reference design (Cohon, J.L. 1998). The selected alternative, EDA II, incorporates a lower thermal load than was assumed for VA. This design alternative addresses NWTRB concerns about the modeling of coupled process in calculating repository performance.

For the vast majority of the radionuclides that would potentially be emplaced in a repository, the Yucca Mountain site alone (the natural barrier system) appears to be capable of containing them and preventing any transport to the accessible environment. A small fraction of the radionuclides appear to be mobile and, under some circumstances, could move out of the potential repository if they are exposed to water. This concern can be mitigated by use of an engineered barrier system to limit the exposure of these radionuclides to the small amount of water moving through the unsaturated zone at the site. A major focus of the repository design process is to identify a sufficient set of engineered barriers to accomplish this task.

Since the LADS recommendation is a conceptual design, the various design elements considered during the study were conceptual in nature. More detailed design activities will occur following the LADS project and prior to the possible SR and LA. By keeping the evaluations at a conceptual design level, the LADS team considered a wide range of design options, despite the differences in data available for various design elements.

2.1 SCOPE

The selected repository concept can be characterized as a low thermal impact design. This design uses more extensive thermal management techniques than the VA design to limit the impacts of the heat released by the waste. These thermal management techniques include thermal blending of SNF assemblies, closer spacing of the waste packages, wider spacing of the waste emplacement tunnels (drifts), and preclosure ventilation. Thermal blending of SNF assemblies reduces the peak heat output of the waste packages, making it easier to limit temperatures in the rock around the waste packages. Closer spacing of the waste packages in the emplacement drifts reduces temperature variations in the drifts, simplifies the analysis of the effects of heat, and reduces the total length of the drifts excavated. Spacing the drifts further apart reduces the effects of the heat from each drift on its neighbors, leaves a wide region of rock between drifts, which stays below the boiling point of water so that water can move around the hot drifts and flow down through the cooler areas, and limits the long-term alterations to the repository rock caused by the heat from the waste. Preclosure ventilation makes it possible to stay within temperature limits in the rock and around the waste packages during operation despite the much closer waste package spacing. It also reduces maximum temperatures after closure by removing energy before closure that would otherwise heat the repository rock.

2.1.1 Basis for Recommendation

The selected design provides a good balance of the ability of lower temperature designs to reduce uncertainties regarding postclosure performance, flexibility, and cost.

2.1.2 Performance

Performance assessment models used for EDA II indicate that the selected design would perform extremely well with respect to a screening criterion of 25 millirem/year to an average member of a critical group living 20 kilometers from the potential repository during the first 10,000 years. A calculated dose rate of 25 millirem/year would not be reached for more than 300,000 years, and the dose rate at any time would be less than 100 millirem/year. The calculated time of the first corrosion failure of a waste package is approximately 100,000 years.

2.1.3 Reduced Uncertainty

EDA II offers a number of advantages for the licensing safety case compared with designs with greater thermal effects. First, it reduces or avoids uncertainties associated with the thermal pulse when large quantities of water could possibly pool above the repository, and then subsequently flow into the drifts where the water could corrode the hot drip shields or waste packages. Second, by allowing only a small amount of the rock mass several meters around the drifts to exceed the boiling point of water for several hundred years, the design reduces the potential for long-term hydrological and geochemical alteration of the host rock. Third, the wide drift spacing reduces the analytical complexities resulting from temperature interactions among closely spaced drifts, simplifying the analysis of repository performance. Fourth, the design does not subject the Alloy-22 waste package material to temperature/humidity conditions conducive to aggressive crevice corrosion. As a result of both thermal conditions and the diversion of water by the drip shield, the Alloy-22 waste package material is subject only to very slow general corrosion.

2.1.4 Construction/Operations

The selected design achieves many of the operational benefits of other LADS designs and the VA design that have more extensive thermal effects in terms of the ability to use larger waste packages and reduce the length of emplacement drifts that must be excavated. EDA II provides operational flexibility by allowing cooler SNF and HLW to be placed into drifts separate from the hotter SNF. This avoids the need for careful staging and sequencing of the emplacement of waste packages containing DOE and commercial nuclear materials assumed in the VA design (DOE 1998b).

2.1.5 Technical and Programmatic Flexibility

The low thermal impact design allows focused progress toward a final design for a possible SR and LA, without precluding future revisions of major program goals or repository design attributes. Specifically, no additional technology development or site characterization would be needed to allow transition to lower temperature goals by extending the preclosure ventilation period. Although the selected design requires more area than the VA design, it still leaves room to accommodate 105,000 metric tons of waste (if such an increase in capacity were authorized) within an area that has already been characterized.

2.1.6 Confirmation and Retrieval

Activities to confirm that a repository is working as expected would begin long before the first waste is emplaced. In the current site characterization phase, information concerning Yucca Mountain and the surrounding environment is being collected and compiled to provide a baseline against which to compare what occurs after the repository is built and waste is emplaced. When repository operations begin, remote sensors will monitor the waste packages, emplacement drifts, and surrounding rock. The monitoring data will be compared to the baseline to determine the observed effects of the repository, and the observed effects will be compared to the model predictions. These confirmation activities will determine whether the repository is performing as expected and will continue until the repository is closed and sealed.

If a problem is detected prior to closing and backfilling the repository, remedial action or retrieval of the waste would be possible using remotely operated equipment. The NRC currently requires that the repository be designed to allow the retrieval of waste at any time up to 50 years after waste operations begin. Any retrieval of waste would follow, in reverse order, the same steps taken in emplacing the waste and, for the most part, would use the same systems and equipment. This cost estimate does not include costs for retrieval.

After the last package is placed underground, the repository could be monitored for many decades, perhaps even centuries. Permanently installed sensors would monitor waste packages, emplacement drifts, and the surrounding rock, providing the data required to confirm performance. A remotely operated inspection gantry would track conditions in the waste emplacement drifts.

2.1.7 Repository Closing

To provide future generations the option of closing the repository or monitoring it for long periods of time, the repository could be designed so it could be kept open from 50 to 300 years after the beginning of emplacement. This analysis addresses two scenarios that reflect the principal options being considered. Case 1 assumes closure 50 years after emplacement starts, as was assumed in the LADS Report (CRWMS M&O 1999c). Case 2 assumes extended ventilation for a total of 125 years after emplacement starts to reflect an approach to meet lower thermal goals.

Permanently closing the repository would require the sealing of all shafts, ramps, exploratory boreholes, and other underground openings. These actions would discourage any human intrusion into the repository and prevent water from entering and radionuclides from escaping through these openings.

At the surface, all radiological areas would be decontaminated, all structures taken down, and all site-generated wastes and debris disposed of at approved sites. The surface area would be restored as closely as possible to its original condition. Permanent monuments would be erected around the site to warn any future generations of the presence and nature of the buried wastes.

2.2 DESIGN DIFFERENCES BETWEEN THE VA AND EDA II

EDA II is compared with the VA design (DOE 1998b) in Table 3. EDA II uses more area than the VA design, but is capable of emplacing 70,000 MTHM within the upper emplacement level and more than 105,000 MTHM in the characterized area. Its wider drift spacing improves drainage and thermal independence of the drifts. Its steel ground support, invert and Alloy-22 waste package pedestal reduce performance uncertainties attributable to the effects of concrete on radionuclide mobilization and transport in the VA design. In EDA II, the waste package corrosion-resistant material, Alloy-22, protects the underlying structural material, stainless steel 316L, from corrosion. In contrast, the VA design had its structural material, carbon steel, covering the corrosion-resistant material, Alloy-22. One reason for the change was the possibility that the failure mode of the VA structural material may accelerate the failure of the corrosion-resistant material.

Table 3. Comparison of Enhanced Design Alternative II and Viability Assessment Design

Design Characteristics	EDA II Design	VA Design
Areal Mass Loading	60 MTHM/acre	85 MTHM/acre
Drift Spacing	81 m	28 m
Drift Diameter	5.5 m	5.5 m
Waste Package Spacing	Line loading: 10 cm	Point loading: Spacing varies (several meters)
Total Length of Emplacement Drifts	54 km	107 km
Ground Support	Steel	Concrete lining
Invert	Steel with sand or gravel ballast	Concrete
Number of Waste Packages[a]	10,039	10,500
Waste Package Materials	2-cm Alloy-22 over 5-cm stainless steel 316L	10-cm carbon steel over 2-cm Alloy-22
Maximum Waste Package Capacity	21 pressurized-water reactor (PWR) assemblies	21 PWR assemblies
Peak Waste Package Power to Average PWR Power (blending)	20% above average PWR package	95% above average PWR package
Drip Shield	2 cm Ti-7	None
Backfill	Yes	None
Preclosure period	50 years & 125 years	50 years
Preclosure ventilation rate	2 – 10 m^3/s	0.1 m^3/s
Performance (Central Estimate)[b] and Cost		
First/Median Drip Shield Failure	9,000/55,000 years	N/A
First/Median Waste Package Failure	100,000/325,000 years	4,000/165,000 years
Performance Margin	103	103
Time to Reach 25 mrem/yr	305,000 years	150,000 years
Peak Dose Rate	85 mrem/yr	330 mrem/yr
Time of Peak Dose Rate	630,000 years	310,000 years

NOTES [a] These waste package counts represent the VA and LADS EDA scope of 70,000 MTU of waste only.

[b] These performance estimates do not represent a licensing case. They are preliminary calculations for conceptual designs.

The installation of drip shields and backfill in EDA II at closure will require reliable operation of remotely controlled equipment in a high-temperature environment with radiation. These tasks are not required in the VA design, although similar capability will be required to respond to off-normal events. The remote installation tasks are mitigated in EDA II by the preclosure ventilation, which limits preclosure drift temperatures to sub-boiling, compared to about 170°C for the VA design. Emplacement of waste packages is also different for the two designs. For the VA design, the waste packages would be emplaced using a gantry that lifts and carries the waste packages by their ends. Due to the smaller gaps between the EDA II waste packages, the waste packages would be emplaced by equipment lifting them from below, but which would back out of the drift after emplacing the pre-assembled waste package and support hardware.

INTENTIONALLY LEFT BLANK

3. MONITORED GEOLOGIC REPOSITORY

3.1 SCOPE

The two essential components of the waste disposal system consist of the monitored geologic repository and robust waste packages (WPs). The monitored geologic repository is assumed to be located at Yucca Mountain about 160 km (100 miles) northwest of Las Vegas, Nevada. The nearest populated area is Amargosa Valley, approximately 20 km to the south. Yucca Mountain itself is a ridge composed of a sequence of tilted layers of variably welded and fractured tuffs. The host rock proposed for the repository is a welded tuff unit of the Topopah Spring Member located at a height of at least 100 meters above the water table and a depth of at least 200 meters below the surface (*Civilian Radioactive Waste Management System Total System Description. 1999.* TDR-CRW-SE-000002 Rev. 02C. Vienna, Virginia.).

The WPs provide containment of the nuclear wastes for thousands of years. The repository host rock ensures that radionuclides released from the WPs do not constitute an unacceptable risk to public health and safety or to the environment, in accordance with standards that are to be developed by the Environmental Protection Agency. The disposal system will operate under a license issued by the NRC, pursuant to the final rule of the currently proposed 10 CFR 63, *Disposal of High-Level Radioactive Wastes in a Geologic Repository at Yucca Mountain, Nevada (64 FR 8640).*

Receipt of waste at the repository is planned to begin in 2010. Although receipt and emplacement rates are assumed to be the same, the actual emplacement rate is a function of the types and sizes of casks and canisters received. Lag storage may be provided at the repository to manage the movement of waste before emplacement and to compensate for any differences between receipt and emplacement rates.

The conceptual repository design consists of surface and subsurface facilities, which constitute the geologic repository operations area, as defined in the proposed 10 CFR 63.2 (64 FR 8640). The statutory capacity of the repository is 70,000 MTHM or equivalent of SNF and HLW until such time as a second repository is in operation. The need for a second repository, however, is to be recommended by the Secretary of Energy to the President between January 1, 2007 and January 1, 2010. Current cost information, designs, or authorization for a second repository do not exist. Therefore, consistent with the 1998 TSLCC, a one-repository system, without interim storage, has been assumed.

3.1.1 Surface Facilities

The nuclear wastes that are destined for disposal in the repository will be received and packaged for emplacement in a 32-hectare (80-acre) area located at the northern entrance to the potential repository (the North Portal Operations Area). The operations involving radioactive materials will be conducted in a Radiologically Controlled Area, which contains the Waste Handling Building (WHB) and other facilities that handle radioactive material. Support operations will be accomplished in the Balance of Plant Area. The Radiologically Controlled Area includes the Carrier Preparation Building, where shipping casks are prepared for removal from rail or truck carriers. SNF assemblies and disposable waste canisters will be packaged for disposal in the

WHB. Within the WHB, there are five processing lines: three wet lines, and two that are dry. The wet processing lines are used to extract SNF assemblies from transportation casks or non-disposable canisters and place them in disposal containers. The dry processing lines only handle HLW or SNF in disposable canisters. The WHB also includes welding stations for sealing the disposal containers, and staging areas for loaded disposal containers waiting to be sealed or WPs awaiting transfer to the subsurface emplacement areas. The Radiologically Controlled Area also includes a Waste Treatment Building for the treatment of low-level waste, a Transporter Maintenance Building for servicing and repairing vehicles that are used for transporting and emplacing WPs in the repository, and may include an Airlock Building at the entrance to the North Portal. The balance of plant area includes: security stations, administrative building, fire/medical center, warehouse, central maintenance shops, motor pool and facility service station, mock-up building for training, utility building, and a visitors center. These are non-Radiologically Controlled Areas.

Other operations areas are included in the surface facilities. The South Portal Operations Area, covering about 30 acres adjacent to the southern entrance to the repository, provides systems and equipment to support the development of subsurface facilities. The surface facility here includes a concrete plant for supplying concrete for in-place casting and basic structures for personnel support, maintenance, warehousing, material staging, security, and transportation. The remaining areas, each of minimal acreage, are the Ventilation Shaft Operations Areas. These areas have systems and equipment that provide ventilation to support development and emplacement operations underground.

The MGR design concept includes a solar power component that will generate power used to offset part of the power requirements of the MGR's ventilation system. The solar component will be of a modular design allowing future expansion of its initial power capability.

3.1.2 Subsurface Facilities

The waste emplacement horizon in the repository will be located in the Topopah Spring Member, a welded tuff unit of the Paintbrush Tuff. At Yucca Mountain, the Topopah Spring Member has a maximum thickness of approximately 350 meters and dips about 6 degrees to the east (CRWMS M&O *Total System Description*, Rev. 02C). Potentially usable emplacement areas are delineated by major faults. These potentially usable areas include a primary area and expansion areas.

The primary area consists of upper and lower blocks bounded on the east by the Imbricate Fault Zone, on the west by the Solitario Canyon Fault, and on the south by the thinning of the Topopah Spring Member in the repository horizon. It is located at least 200 meters below the surface and at least 100 meters above the regional water table (CRWMS M&O *Total System Description*, Rev. 02C, p. 15.). The lower block is nominally 70 meters below and 200 meters east of the upper block. The Ghost Dance Fault separates the upper block (west of the fault) from the lower block. Expansion areas are potentially available; however, additional characterization activities would be required to validate much of these areas. These areas lie west of the Solitario Canyon fault.

The five miscellaneous drifts will remain empty during emplacement operations. Three of the empty drifts will be designated as cross-block drifts and will be used to facilitate ventilation, emergency egress, and Performance Confirmation (PC) monitoring. The remaining two empty drifts will serve as standby drifts for relocating WPs, if necessary.

The ramps and main drifts are 7.6 meters in diameter and are used for waste transport, ventilation, service utilities, and personnel access. The North and South Ramps and the main drifts have grades of less than 3 percent to ensure the safe use of heavy-rail transport to the emplacement horizon (CRWMS M&O *Total System Description, Rev. 02C, p. 15*).

The dual central exhaust drifts, located side by side beneath the emplacement block, are interconnected and provide exhaust ventilation for the emplacement drifts. They are connected to each of the emplacement drifts by raises (small shafts vertically bored).

Emplacement drifts are 5.5 meters in diameter, and are spaced at 81 meters between the centers of each drift. Each emplacement drift has a door at each end of the drift to control access. Each door has ventilation regulators (louvers) to control the flow of air through the emplacement drift. These doors are remotely controlled from the surface control room. A portion of the total number of emplacement drifts will be developed prior to the start of emplacement operations. Development of the remaining emplacement drifts will be performed concurrently with waste emplacement during the repository operations phase, using two separate and independent ventilation systems. One system will provide ventilation for the excavation operations required for drift development, while the other will provide ventilation for the waste emplacement operations. Movable temporary walls (isolation air locks) installed in the main drifts at the points that divide the two operations will keep the two ventilation systems separate. As excavation and emplacement operations progress, these walls will be moved to new positions in the main drifts, thus providing access to the newly excavated drifts for waste emplacement.

The ventilation system that supports drift development operations will force air into the drifts by way of surface-located fans at the intake shaft; exhaust air through the South Portal ramp; and maintain air pressure in the development area above that in the emplacement area.

The ventilation system that supports waste emplacement operations will pull air through the North Portal ramp and the air intake shaft into the emplacement area, using surface-located fans at the exhaust shafts. It will also exhaust air through the exhaust shafts and maintain air pressure in the emplacement area below that in the excavation area.

The ventilation system maintains a maximum temperature suitable for human occupancy in areas where personnel are working. Personnel are not allowed in the emplacement drifts during emplacement operations.

3.2 ASSUMPTIONS

This analysis assumes, for cost estimating purposes, a single repository at Yucca Mountain capable of handling all projected waste streams of SNF and HLW currently forecasted. The subsurface layout is an extrapolation of the current Yucca Mountain design described in the VA (DOE 1998b). The NWPA (DOE 1995b) specifies that the need for a second repository will be assessed between 2007 and 2010.

NRC regulations for licensing the repository (10 CFR 60) require that a geologic repository be designed for waste retrieval starting any time up to 50 years after initiation of waste emplacement operations. Compliance with these requirements means that the repository must be designed to be kept open for a number of years after the last waste has been emplaced. Future generations will decide how long to maintain the repository in an open, monitored condition, whether to retrieve the waste, and when to permanently close the repository. To ensure future decision-makers have flexibility regarding these decisions, the repository is being designed with the capability to be closed as early as 50 years from the initiation of waste emplacement, or to remain open for up to 300 years with appropriate monitoring and maintenance.

This estimate provides two cases for the length of the monitoring phase that precedes closure and decommissioning activities. Case 1 assumes closure and decommissioning beginning 50 years after the start of emplacement, and Case 2 assumes closure and decommissioning beginning 125 years after the start of emplacement.

The MGR assumptions for the 1999 TSLCC are extracted from the EDA II section of the LADS Report (CRWMS M&O 1999c). There are three key differences between the 1999 TSLCC assumptions and the EDA II cost assumptions in the LADS Report. The first difference is that the TSLCC addresses the costs for management and disposal of more wastes. The second difference is the inclusion of all WAST costs for bringing the waste to the repository, Program Integration costs, and Institutional costs. The last difference is the inclusion of all costs from program inception in 1983 to LA in 2002.

3.2.1 Surface Facility

Key surface facility assumptions that differ from the VA design are as follows:

1. The fuel pool storage facility, with a capacity for 3,750 MTHM, was added to enable the blending requirements.

2. A solar power facility will be constructed as part of the repository. The energy generated by the solar facility will be supplied to the power grid instead of directly to any repository facility.

3.2.2 Subsurface Facility

Key subsurface facility assumptions that differ from the VA design are as follows:

1. Drip shields of Titanium-7 corrugated plate will be installed over all WPs.

2. Backfill in the form of quartz sand will be placed in all emplacement drifts.

Key subsurface facility assumptions that differ from the EDA II design in the LADS Report (CRWMS M&O 1999c) are as follows:

1. The subsurface emplacement area will be expanded to the characterized lower block to accommodate all planned waste quantities in the CRD (DOE 1999a).

2. The cost for ventilation will be based on the flow rate of 10 cubic meters per second for 50 years in Case 1 and 125 years in Case 2. The EDA II design listed the ventilation rate as a range from 2 to 10 cubic meters per second. The cost estimate for the EDA II design in the LADS Report used 2 cubic meters per second for ventilation in its estimate. The TSLCC estimate takes a conservative cost approach and uses the higher 10 cubic meters per second assumption for ventilation. Also, preliminary analysis subsequent to the LADS Report indicated the need for higher ventilation to meet thermal requirements.

3.2.3 Waste Package

The only WP assumption that differs from the LADS Report (CRWMS M&O 1999c) is the quantity. The CRWMS Analysis and Logistics Visually Interactive (CALVIN) model (CRWMS M&O 1999e) was used to calculate the number of waste packages for the EDA II blending assumptions. CALVIN is a planning tool that estimates the logistic and cost impacts of various operational assumptions in accepting radioactive wastes. The following CALVIN parameters were used to model the blending impacts:

1. The single assembly heat limits for the WPs were disabled; this simulated blending by ensuring that all assemblies are placed in a WP. This assumes that hot fuel will be mixed with cooler or aged fuel, so that total WP heat does not exceed design limits.

2. The small PWR waste package type was removed from the list of waste package designs since it was only needed for its higher thermal capability.

3. South Texas fuel continues to have its own small WP.

4. The small boiling water reactor (BWR) WP was only used for its higher criticality capability.

3.3 COSTS

The MGR cost estimate is comprised of integrated costs from six scope elements:

- Surface
- Subsurface
- Performance Confirmation
- Waste Package
- Development and Evaluation (D&E)
- Regulatory, Infrastructure, and Management Support (RIMS).

Table 4 provides, by phase, historical and future costs for both Case 1 and Case 2. Detailed costs for each of the phases in Table 4 are presented in the remainder of Section 3.

Table 4. Repository Costs by Phase (in Millions of 1999$)

Phase	Historical (1983-1999)	Case 1 Future Costs (2000-2069)	Case 2 Future Costs (2000-2144)
Development & Evaluation (1983-2002)	5,340	740	740
Licensing (2002-2005)	0	760	760
Pre-Emplacement Construction (2005-2010)	0	3,220	3,220
Emplacement Operations (2010 – 2041)	0	18,030	18,030
Monitoring	0	2,320	6,750
Closure and Decommissioning	0	7,060	7,080
Total	**5,340**	**32,130**	**36,580**

NOTE: Historical costs total $4.4 Billion in YOE dollars; 1999 historical costs are an estimate.

3.3.1 Repository Development and Evaluation

The repository D&E phase began with program inception and continues until the submittal of a LA in March 2002. Repository D&E activities include all of the site characterization and preliminary design development activities associated with the repository.

Repository D&E costs are summarized in Table 5. Historical costs are divided into two categories: The costs associated with the repository at Yucca Mountain, and all other costs for site characterization activities. The other repository historical costs include technical support, the repository technology program, and the salt and basalt sites that were formerly considered for the first repository program. Future costs are projected only for a repository based upon the Yucca Mountain site. All site characterization activities at other sites have been terminated in accordance with the Nuclear Waste Policy Act (NWPA), Section 161 (DOE 1995b).

Table 5. Repository Development and Evaluation Costs (in Millions of 1999$)

Phase	Historical (1983-1999)	Case 1 and 2 Future Costs (2000-2002)
Repository Development and Evaluation at Yucca Mountain	5,220	740
Other Repository Development and Evaluation	120	0
Repository D&E Total	**5,340**	**740**

NOTE: Historical costs total $4.4 Billion in YOE dollars; 1999 historical costs are an estimate.

3.3.2 Licensing

The repository licensing phase begins with the submittal of the LA in March 2002 and continues until construction authorization in 2005. This phase includes activities supporting limited procurement activities, such as the acquisition of long-lead construction materials and equipment for surface and subsurface facilities. Table 6 details the costs for the licensing phase.

Table 6. Repository Licensing Costs (in Millions of 1999$)

Cost Element	Case 1 and 2 Future Costs (2002-2005)
Surface	160
Subsurface	110
Waste Package and Drip Shield Fabrication	39
Performance Confirmation	110
Regulatory, Infrastructure & Management Support	340
Licensing Total	**760**

3.3.3 Pre-Emplacement Construction

The pre-emplacement construction phase covers the period from construction authorization in 2005 through early 2010. This phase includes costs for MGR procurement, design, and construction. Construction includes costs for site preparation, and construction of surface and subsurface facilities. Additionally, costs are included for startup and training. Table 7 details the costs for the pre-emplacement phase.

Table 7. Repository Pre-Emplacement Construction Costs (in Millions of 1999$)

Cost Element	Case 1 and 2 Future Costs (2005-2010)
Surface	1,320
Subsurface	1,160
Waste Package and Drip Shield Fabrication	83
Performance Confirmation	190
Regulatory, Infrastructure & Management Support	470
Pre-Emplacement Construction Total	**3,220**

3.3.4 Emplacement Operations

The emplacement operations phase covers the period from 2010-2041. It includes all costs for staffing, maintenance, supplies and utilities during waste emplacement; completing the underground facilities; and procurement of WPs. Table 8 details the costs for the emplacement phase.

Table 8. Repository Emplacement Operations Costs (in Millions of 1999$)

Cost Element	Case 1 and 2 Future Costs (2010-2041)
Surface	4,640
Subsurface	4,360
Waste Package and Drip Shield Fabrication	7,120
Performance Confirmation	890
Regulatory, Infrastructure & Management Support	1,020
Pre-Emplacement Construction Total	**18,030**

3.3.5 Monitoring Operations

The monitoring operations phase covers the period from 2041 through 2060 for Case 1, and 2041 through 2135 for Case 2. It includes all costs for staffing, maintenance, supplies, ventilation of the emplacement drifts, and utilities. It also includes the recovery costs for separately emplaced samples of WP material that will be used for PC testing during this phase. Table 9 details the costs for the monitoring phase.

Table 9. Repository Monitoring Costs (in Millions of 1999$)

Cost Element	Case 1 Future Costs (2041-2060)	Case 2 Future Costs (2041-2135)
Surface	440	1,020
Subsurface	640	3,130
Waste Package & Drip Shield Fabrication	790	810
Performance Confirmation	260	1,150
Regulatory, Infrastructure & Management Support	190	640
Monitoring Total	**2,320**	**6,750**

3.3.6 Closure and Decommissioning

The closure and decommissioning phase covers the period from 2060 through 2069 for Case 1, and 2135 through 2144 for Case 2. It includes all costs to fabricate and install drip shields; backfill emplacement drifts, shafts, ramps, mains, and extension drifts; permanently seal the underground repository; dismantle surface facilities; and construct monuments. Table 10 details the costs for the closure and decommissioning phase.

Table 10. Repository Closure and Decommissioning Costs (in Millions of 1999$)

Cost Element	Case 1 Future Costs (2060-2069)	Case 2 Future Costs (2135-2144)
Surface	160	160
Subsurface	1,240	1,240
Waste Package & Drip Shield Fabrication	5,480	5,480
Performance Confirmation	6	21
Regulatory, Infrastructure & Management Support	180	180
Closure & Decommissioning Total	**7,070**	**7,080**

The NRC currently requires that the repository be designed to allow the retrieval of waste at any time up to 50 years after waste operations begin. However, the cost for the contingency of retrieving WPs is not included in this analysis.

4. WASTE ACCEPTANCE, STORAGE AND TRANSPORTATION

4.1 SCOPE

DOE will rely on the private sector to provide the necessary services and equipment required to accept and transport commercial SNF to the repository. These services and equipment will be procured by awarding one or more contracts, with each contract covering Purchasers' sites in certain designated regions in the contiguous United States. Purchasers are those owners of commercial SNF who have entered into contracts with DOE for disposal of their SNF. Each CRWMS regional servicing contractor (RSC) will be responsible for all activities and services in its region, including the provision of transportation cask/canister systems and ancillary equipment to accept commercial SNF and transport it to the repository for disposal. Specific performance requirements for each RSC will be set forth in detail in the procurement documents.

Transportation will be carried out using commercially available equipment and approved routes in compliance with NRC and Department of Transportation regulations. To the extent practicable, DOE will rely on the private sector to provide the necessary services and equipment to accept and transport HLW and DOE SNF (except naval SNF) to the repository. The U.S. Navy will provide transportation of its SNF to the repository.

The waste acceptance and transportation elements of the CRWMS will accept commercial SNF, including MOX fuel, from commercial reactors; DOE SNF and HLW from DOE sites; and HLW and SNF from West Valley; and will transport the materials to the repository. The operational waste acceptance element provides the interface between the CRWMS, the utilities, and DOE sites to maintain contracts and agreements, verify records, verify loading and accept the waste, and maintain material control and accounting. The operational transportation element is responsible for the shipment of SNF and HLW to the repository. Transportation costs do not include the cost for shipping naval SNF to the repository. However, costs for decommissioning the transportation casks at the end of operations are included. Under the current plan, commercial reactors will store commercial SNF on site until acceptance and transport to the repository.

The Waste Acceptance cost category includes the following activities: 1) development of a process for the orderly transfer of SNF and HLW into the Federal system consistent with the needs of both the Federal Government and the owners and generators; 2) development and maintenance of a plan to carry out the Program's waste acceptance responsibilities; 3) development of a collaborative dialogue with the Nation's nuclear utility companies as well as other owners and interested stakeholders; 4) verification of the fees collected for commercial SNF; 5) maintenance and implementation of the provisions in the Standard Contract (10 CFR 961); and 6) provision of contingency planning support, studies, and analyses directed toward the competitive private sector transportation strategy.

4.2 ASSUMPTIONS

As a basis for planning, OCRWM uses the no-new-orders, end of reactor life case, referenced in the *WAST-Cost Estimate Assumptions Document* (CRWMS M&O 1998b). For commercial SNF, this case does not assume additional early reactor shutdowns or service life extensions that would reduce or increase projected quantities of SNF, respectively. Commercial SNF, DOE SNF, and HLW pickup is assumed to begin in 2010. Initial acceptance rates for DOE SNF and HLW are assumed to be low until 2015. Commercial fuel pickup assumes that the youngest fuel greater than or equal to 10 years old is picked up from the sites first. Allocation rights for commercial SNF will be assigned to Purchasers using the oldest fuel first, in accordance with the *Acceptance Priority Ranking and Annual Capacity Report (APR/ACR)* (DOE 1995a) and agreements with the utilities. Table 11 shows the acceptance rate for commercial SNF by MTHM per year. Decommissioning activities are assumed to begin at the conclusion of shipping activities and continue for a year.

Table 11. Acceptance Rates of Commercial Spent Nuclear Fuel

Year	**Acceptance Rate (MTHM/year)**
1999 – 2009	0
2010	400[a]
2011	600
2012	1,200
2013	2,000
2014	3,000
2015 – 2040	3,000
2041	1,117
Total	**86,317**

[a]Since acceptance starts March 31, 2010, an acceptance rate of 400 MTHM/year results in approximately 200 MTHM in FY 2010.

All commercial SNF is stored at utility sites prior to being transported to the MGR. Neither storage nor "take title" costs at utility sites are included in this TSLCC analysis. The cost of MOX SNF transportation casks and transportation from utility sites to the MGR is included in this TSLCC analysis as part of the commercial allocation. MOX SNF is assumed to be transported in a commercial 21-PWR uncanistered fuel cask containing only 9 assemblies.

It is assumed that DOE SNF will arrive in disposable canisters. The canisters will contain various quantities of fuel assemblies depending on fuel types and characteristics. Transportation casks for DOE SNF are assumed to contain from one to six disposable canisters per cask, depending on fuel type.

The quantity of DOE SNF (Table 12) was based on a DOE-furnished integrated database (CRWMS M&O 1998a), and was used in the development of transportation-related costs. Transportation costs of DOE materials are included in the TSLCC analysis, with the assumption that transportation is to be via round trip one-car rail general freight. Development and procurement of transportation casks for DOE SNF are not part of the CRWMS as these casks will be designed and purchased by the DOE without funds from OCRWM. Therefore, these costs are excluded from the TSLCC estimate. Prior to acceptance into the transportation system, DOE SNF is placed in canisters at the DOE facilities managing the nuclear material. The costs for transportation of naval SNF are not included in the TSLCC. The U.S. Navy will provide transportation of naval SNF to the MGR.

Table 12. Acceptance Rates of DOE Spent Nuclear Fuel

Year	Acceptance (Canisters)	Year	Acceptance (Canisters)
2010	1	2023	141
2011	1	2024	161
2012	3	2025	232
2013	6	2026	237
2014	8	2027	229
2015	109	2028	236
2016	150	2029	253
2017	116	2030	250
2018	206	2031	253
2019	172	2032	248
2020	200	2033	138
2021	204	2034	100
2022	144	2035	59
Total			**3,857**

HLW (Table 13) is based on projections of vitrified tank wastes from Hanford, Savannah River Site (SRS), Idaho National Engineering and Environmental Laboratory (INEEL), and West Valley (WV) Demonstration Project (CRWMS M&O 1998a). All HLW is transported to the repository in rail transportation casks, which will be certified by the NRC. HLW rail transportation costs are based on round-trip general freight shipping charges. Costs for vitrification of HLW, by WV and DOE facilities that manage these tasks, are not included in this estimate. The costs for transportation cask design, acquisition, and transport of HLW from the DOE producer sites to the MGR are included in the total program costs. Defense HLW includes 18 metric tons of IPWF, which equals approximately 635 HLW canisters containing plutonium that are back-filled with vitrified HLW.

Table 13. Acceptance Rates of High-Level Waste

Year	Acceptance Rate (Canisters)
2010 - 2014	150
2015	355
2016	376
2017 - 2018	430
2019	420
2020 - 2025	395
2026 - 2028	375
2029 - 2031	455
2032	450
2033	255
2034 - 2035	1,475
2036	1,471
2037 - 2040	1,450
2041	1,457
Total	**20,004**

This analysis assumes that 18 transportation cask designs are required. Specifically, the assumed cask designs include two for commercial legal-weight truck (LWT) transportation, nine for commercial SNF rail, five for DOE SNF rail transportation, and two for HLW rail transportation. Cask design assumptions are based on the fuel type, whether for a PWR or a BWR, size, and thermal properties of all fuel assemblies expected to be transported to the repository for disposal. Costs for acquisition, maintenance, refurbishment, and decommissioning of transportation casks are included, with the exception of DOE casks. The costs for DOE transportation cask acquisition and maintenance are not part of the CRWMS. Contingencies on cask cost estimates are assumed to be sufficient to procure any specialty casks required to accommodate assemblies that cannot be accommodated by 1 of the 18 designs.

Table 14 provides an estimate of the size of the required transportation cask fleet. This cost estimate assumes a competitive private sector approach for the transportation of waste to the repository. This approach assumes DOE contracts for commercial SNF transportation with four separate RSCs, who acquire a cask fleet and provide shipping for their region. This estimate does not assume any sharing of transportation assets between regions. In addition, a separate RSC will transport all HLW and DOE SNF. Actual cask fleet size will be determined upon contracting with RSCs. The cost estimate assumes all rail shipments to the repository are via one-car general freight.

Table 14. Transportation Cask Fleet

Cask Type	Quantity
Commercial Legal-Weight Truck	
BWR – 9 assembly capacity	5
PWR – 4 assembly capacity	8
Commercial Rail	
Large – PWR 24 or 26 assembly capacity Large – BWR 56 or 68 capacity	39
Medium – PWR 21 assembly capacity Medium – BWR 44 assembly capacity	22
Small – PWR 12 assembly capacity Small – BWR 32 assembly capacity	15
High Heat – PWR 12 assembly capacity High Heat – BWR 32 assembly capacity	7
South Texas – 17 assembly capacity	3
Yankee Rowe – 36 assembly capacity	1
Big Rock Point – 64 assembly capacity	1
West Valley – PWR 20 assembly capacity	1
West Valley – BWR 44 assembly capacity	1
HLW Rail	
Long (five 15-foot canisters)	14
Short (five 10-foot canisters)	8
DOE SNF Rail	
4 canister capacity	3
3 canister capacity	4
6 canister capacity	2
5 canister capacity	1
1 canister capacity	1

4.3 COST

The CALVIN model (CRWMS M&O 1999e) was used to calculate transportation costs. Transportation costs do not include the cost for shipping naval SNF. Under the current plan, commercial reactors will store commercial SNF on site until acceptance and transport to the repository. Table 15 summarizes all waste acceptance and transportation costs, including Nevada rail construction and operation costs.

Table 15. Summary of Waste Acceptance, Storage and Transportation Costs by Phase (in Millions of 1999$)

Phase	Historical (1983-1999)	Future Costs (2000-2042)
Development & Evaluation (1983-2005)	490	36
Mobilization, Acquisition, and Construction (2005-2010)	0	820
Waste Acceptance and Transportation Mobilization and Acquisition	0	110
Nevada Transportation Engineering and Construction	0	710
Operations & Acquisition (2010-2042)	0	5,070
Waste Acceptance and Transportation Operations and Acquisition	0	4,990
Nevada Transportation Operations	0	80
Total	**490**	**5,930**

NOTE: Historical costs total $0.4 Billion in YOE dollars; 1999 historical costs are an estimate.

4.3.1 Waste Acceptance, Storage and Transportation D&E

The D&E phase for the waste acceptance and transportation elements began with program inception and will continue until the acquisition of transportation equipment begins in 2005. D&E activities include planning technical assistance for training pursuant to the NWPA, Section 180(c) (DOE 1995b), establishing contracts with RSCs, establishing waste form criteria for DOE wastes, systems engineering, technology demonstration, quality assurance, and environmental safety and health activities. Costs for the storage and multi-purpose canister (MPC) elements were for activities that have been canceled or suspended, and additional costs are not expected in the future. Table 16 provides costs for D&E activities.

Table 16. Waste Acceptance, Storage and Transportation Design and Evaluation Costs (in Millions of 1999$)

Cost Element	Historical (1983-1999)	Future Costs (2000-2005)
Storage	210	0
National Transportation	210	22
Waste Acceptance	24	7
Multi-Purpose Canister Project	38	0
Project Management & Integration	9	7
Total	**490**	**36**

NOTE: Historical costs total $0.4 Billion in YOE dollars; 1999 historical costs are an estimate.

4.3.2 Waste Acceptance and Transportation Mobilization and Acquisition

The WAST Project mobilization and acquisition phase begins in 2005, and continues until acceptance operations begin in 2010. After contracts are awarded for mobilization and acquisition, the RSCs will perform waste acceptance and transportation activities. The activities include establishing agreements with each site regarding schedule, procuring and licensing of transportation hardware, and contracting for rail and truck shipments of SNF to the repository. Table 17 shows the costs for the mobilization and acquisition phase.

Table 17. Waste Acceptance and Transportation Mobilization and Acquisition Costs (in Millions of 1999$)

Cost Element	Future Costs (2005 - 2010)
National Transportation	91
Waste Acceptance	10
Project Management & Integration	10
Total	**110**

4.3.3 Waste Acceptance and National Transportation Operations

The operations phase begins in 2010, when acceptance and transportation of SNF and HLW from sites to the repository starts. The operations phase concludes in 2042 when all SNF and HLW have been transported to the repository, and the transportation casks have been decommissioned. During this phase, continuing acquisition of transportation hardware occurs to handle increases in throughput and transportation equipment replacement. Table 18 shows the costs for waste acceptance and national transportation during the operations phase.

Table 18. Waste Acceptance and Transportation Acceptance Operation Costs (in Millions of 1999$)

Cost Element	Future Costs (2010 - 2042)
National Transportation	4,930
Waste Acceptance	57
Total	**4,990**

The cost basis for railroad shipping rates for nuclear waste is unchanged from the 1998 TSLCC estimate (DOE 1998a). There is historical precedence that indicates that lower costs may be achievable; however, there is uncertainty regarding the ultimate shipping rates that will be effective when shipment of SNF and HLW occurs on an ongoing basis.

4.3.4 Nevada Transportation

The Nevada transportation engineering and construction phase begins in 2002 and concludes in 2010 with the start of emplacement operations. Activities include the design and construction of a branch rail line in Nevada to the repository site. Since no specific rail routing has been determined, the estimated cost is the average cost of five studied route options. An overall contingency of 60 percent was included to allow for cost estimating uncertainty (15 to 25 percent) and route uncertainty. Nevada rail transportation operations begin in 2010, and continue until the end of emplacement in 2042 including an additional year for decommissioning activities. Table 19 shows the Nevada transportation costs.

Table 19. Nevada Transportation Costs (in Millions of 1999$)

Cost Element	Future Costs (2002-2042)
Engineering & Construction (2002-2010)	710
Emplacement Operations (2010-2042)	80
Total	**790**

5. PROGRAM INTEGRATION

5.1 SCOPE

Program Integration activities include Quality Assurance (QA), Systems Integration and Regulatory Compliance represented as Program Management and Integration (PM&I), and Human Resources and Administration. Program Integration activities that are outside of the OCRWM budget and are funded from the Nuclear Waste Fund (NWF) include NRC costs, the NWTRB, and costs for the defunct office of the Nuclear Waste Negotiator (NWN).

5.1.1 Quality Assurance

The OCRWM program maintains a mandatory QA program to identify and ensure implementation of requirements that protect the health and safety of the public, workers, and the environment. The QA program must meet NRC requirements. Extensive development and review of technical and implementation documentation, as well as effective implementation of the requirements, will be necessary to ensure sound data and engineering, and to support eventual licensing of facilities by the NRC. Through QA audits, the QA program independently verifies that the various designs and scientific activities incorporate the necessary regulatory requirements. The QA program includes work scope related to providing QA program management advice and planning, establishing and maintaining the OCRWM QA program and implementing procedures, and conducting QA verification activities. QA activities are assumed to continue through closure and decommissioning of the repository in 2069 for Case 1 and 2144 for Case 2.

5.1.2 Program Management and Integration

PM&I activities support the Program Director in communicating program policy to key audiences internal and external to the DOE, and in articulating the rationale for strategy and plan changes to program stakeholders. Support is provided for the Program Director's interactions with Congress and the Office of Management and Budget (OMB) during the appropriations process. PM&I staff also support interactions with the NWTRB in its independent evaluation of the program's technical and scientific activities.

PM&I has five areas of work: Systems Engineering and Integration, Regulatory Compliance, Planning, International Waste Management Technology, and Program Control. The costs for the salaries, travel expenditures, and overhead charges of Federal employees who support the OCRWM program, located at all sites, are included in the PM&I cost estimate.

Future PM&I costs are projected to decrease relative to historical costs for this element. There is a high integration component during the D&E phase of the program. Program Integration costs are expected to decrease as the program proceeds with implementation, and will be significantly reduced during the monitoring phase.

5.1.3 Human Resources and Administration

Human Resources and Administration manages a diverse set of personnel development, communication, financial, and information management programs. These include QA training for headquarters personnel, submittal of the Annual Report to Congress, management of the NWF investment portfolio, public information and education activities, administration of scholarship programs, and implementation of information management systems.

5.1.4 Nuclear Regulatory Commission Costs

NRC costs cover that agency's operating costs for participating in the CRWMS Program. Funds for NRC activities that support the program are appropriated separately by Congress as part of the NRC budget rather than the DOE budget. The CRWMS portion of the NRC budget is paid from the NWF. Consequently, NRC costs are included in the TSLCC analysis. NRC costs began in 1989 and are assumed to continue through closure and decommissioning of the repository in 2069 for Case 1 and 2144 for Case 2.

5.1.5 Nuclear Waste Technical Review Board

The costs for the NWTRB cover the formation and operation of an independent establishment in the Executive branch of government. The Board, consisting of 11 members appointed by the President, evaluates the technical and scientific validity of the activities undertaken by the Secretary of Energy. Funds for the Board's activities are appropriated from the NWF. The Board's activities began in 1990 and are assumed to continue through receipt of SNF at the repository in 2010.

5.1.6 Nuclear Waste Negotiator

The costs for the Office of the Nuclear Waste Negotiator covered the formation and operation of an independent establishment within the Executive branch of government. The Negotiator, appointed by the President, attempted to find a state or Indian tribe willing to host a Monitored Retrievable Storage (MRS) facility at a technically qualified site. The funds for these activities were appropriated from the NWF. The Negotiator's activities began in 1990 and were terminated in 1995.

5.2 ASSUMPTIONS

The only changes to the Program Integration estimate from the 1998 TSLCC are the use of FY 1998 actual costs (CRWMS M&O 1999b) and the FY 2000 budget request (Barrett, L.H. 1999).

5.3 COST

Table 20 summarizes Program Integration costs. The Program Integration costs have not changed significantly from the 1998 TSLCC estimate.

Table 20. Program Integration Costs (in Millions of 1999$)

Cost Element	Historical (1983-1999)	Case 1 Future Costs (2000-2069)	Case 2 Future Costs (2000-2144)
Program Management & Administration	1,290	1,820	2,210
Quality Assurance	110	560	560
Program Management & Integration	1,010	1,050	1,370
Human Resources & Administration	170	210	280
Non-OCRWM NWF Costs	300	320	400
Nuclear Regulatory Commission	260	290	370
Nuclear Waste Technical Review Board	25	27	27
Nuclear Waste Negotiator	10	0	0
Total	**1,590**	**2,140**	**2,610**

NOTE: Historical costs total $1.3 Billion in YOE dollars; the 1999 historical costs are an estimate.

INTENTIONALLY LEFT BLANK

6. INSTITUTIONAL

6.1 SCOPE

Cost elements defined as Institutional cover scope that is prescribed by the NWPA (DOE 1995b) but do not affect design, construction, operations, monitoring, or closure and decommissioning activities of the MGR. These cost elements are PETT, benefits, 180(c) assistance, and financial assistance.

6.1.1 Payments-Equal-To-Taxes

The NWPA authorized the Secretary of Energy to grant, to affected states and units of local government, an amount each fiscal year equal to the amount a state or affected unit of local government, respectively, would receive if authorized to tax DOE activities the same as commercial activities. States and units of local government are entitled to PETT for real property and industrial activities, including site characterization activities and development and operation of a repository. PETT costs are neither a tax nor a payment of tax, but rather a payment under the NWPA (DOE 1995b).

The commencement date for repository-related PETT eligibility was May 28, 1986, the date the President approved sites in Nevada, Texas, and Washington as candidates for site characterization. The termination date for PETT eligibility for repository-related site characterization activities at the Texas and Washington sites was December 22, 1987, the date the amended NWPA suspended site characterization at the two sites. The State of Nevada and local jurisdictions in Nevada and California remain eligible for PETT through facility decommissioning of the repository site at Yucca Mountain in 2069 for Case 1 and 2144 for Case 2.

6.1.2 Benefits

The NWPA (DOE 1995b) allows the Secretary of Energy to enter into benefits agreements with the State of Nevada or affected Indian tribes pertaining to a repository for the acceptance of HLW or SNF. The Act states that the state or Indian tribe in which the repository is located is eligible to receive annual payments commencing on the date a repository site agreement is signed, and ending with the decommissioning of the repository. In return for these benefits, the state or Indian tribe waives its rights to disapprove the recommendation of a specific site.

6.1.3 180(c) ASSISTANCE

Section 180(c) of the NWPA (DOE 1995b) directs OCRWM to provide resources for planning, technical assistance, and training to states and tribal lands passed through by the shipment of spent nuclear fuel.

6.1.4 Financial Assistance

The program has been providing the State of Nevada, local counties, and educational institutions with financial assistance from 1983 through the present.

6.2 ASSUMPTIONS

On July 27, 1994, the Director of OCRWM signed a negotiated PETT settlement agreement with Nye County, Nevada, for the tax period from May 28, 1986, through tax year 1998-1999. The Director of OCRWM signed a second agreement on July 26, 1999, for the tax period from July 1999 through tax year 2002-2003. PETT costs to the State of Nevada and other local jurisdictions in Nevada and California for 2004 through 2069 for Case 1, and through 2144 for Case 2, are based on estimates provided by the Yucca Mountain Site Characterization Project Office. Assumed PETT costs average $10 million per year plus a 36 percent contingency for Case 1 and an 18 percent contingency for Case 2. Annual PETT costs will depend on negotiations with local jurisdictions based on activities at the site.

Annual Benefit amounts are established in the NWPA (DOE 1995b). Payments made prior to the acceptance of SNF will be at the rate of $10 million per year; payments made after the receipt of SNF will be at the rate of $20 million per year. These payments are not indexed for inflation; therefore, annual payments are adjusted to constant 1999 dollars for purposes of this estimate. It is assumed, for the purposes of this estimate, that the Secretary of Energy enters into a benefits agreement with the State of Nevada in 2002. Annual payments will then be made to the state at the rate of $10 million per year from 2002 through 2009. From the first spent fuel receipt at the repository in 2010, until closure of the repository in 2060 for Case1 and 2135 for Case 2, annual payments to the state will be $20 million per year. The NWPA, Section 172(a), (DOE 1995b), requires that a six-member Review Panel be established to advise the Secretary on matters relating to the proposed repository, including issues relating to design, construction, operation, and decommissioning of the facilities. The Review Panel and associated costs are assumed to begin with panel selection in 2001.

6.3 COST

Costs are presented in Table 21 for the elements that comprise Institutional: PETT, Benefits, 180(c) Assistance, and Financial Assistance.

Table 21. Institutional Costs (in Millions of 1999$)

Cost Element	Historical (1983-1999)	Case 1 Future Costs (2000-2069)	Case 2 Future Costs (2000-2144)
PETT	44	2,740	3,030
Benefits	0	500	590
180(c) Assistance	1	460	460
Financial Assistance	180	25	25
Total	**230**	**3,730**	**4,110**

NOTE: Historical costs total $0.2 Billion in YOE dollars; 1999 historical costs are an estimate.

The PETT costs are the only one of the four Institutional elements that has a changed scope from the 1998 TSLCC. Other cost elements have changed in value due to the differences in the operating period and the change in escalation rates used for discounting. PETT costs have increased primarily due to the sales tax and use tax applied to the fabrication of drip shields.

7. COST SHARE ALLOCATION

The CRWMS is funded on a full-cost recovery basis, with generators of waste funding their respective disposal costs. The allocation of estimated CRWMS costs to civilian SNF and HLW and government-managed nuclear material (inclusive of DOE SNF and HLW) are shown for both Case 1 and 2 in Tables 22 and 23, respectively. In these tables, PETT, Benefits, and Nevada transportation costs are included with the repository costs. Historical second repository costs are included with the Program - Unassigned costs.

Table 22. Summary of Civilian Radioactive Waste Management System Cost Share Allocations For Case 1 (in Millions of 1999$)

Category	Cost Share Allocation		
	Government-Managed Nuclear Material	**Civilian**	**Total**
Monitored Geologic Repository	**12,160**	**29,510**	**41,670**
Assigned	7,240	17,580	24,820
Unassigned	4,920	11,930	16,850
Allocation Percent	29.2%	70.8%	100%
Waste Acceptance, Storage & Transportation	**1,310**	**4,760**	**6,070**
Assigned	1,140	4,130	5,270
Unassigned	170	630	800
Allocation Percent	21.6%	78.4%	100%
Program – Unassigned	**1,070**	**2,760**	**3,830**
Allocation Percent	27.9%	72.1%	100%
Total	**14,540**	**37,030**	**51,570**
Aggregate Allocation Percent	28.2%	71.8%	100%

NOTE: Totals may not add or compare with other totals due to independent rounding.

The allocation is based on the methodology published in the August 20, 1987 *Federal Register Notice* (52 FR 31508). In accordance with the *Federal Register Notice* methodology, the costs of activities performed solely for the disposal of a specific type of waste, whether civilian or government-managed, are directly assignable to the waste generators. The remainder of the program costs is appropriately shared preventing cross-subsidization between waste generators, and ensuring that each bears the full cost of disposal of its wastes.

Table 23. Summary of Civilian Radioactive Waste Management System Cost Share Allocations For Case 2 (in Millions of 1999$)

Category	Cost Share Allocation		
	Government-Managed Nuclear Material	Civilian	Total
Monitored Geologic Repository	**13,760**	**32,730**	**46,490**
Assigned	8,520	20,260	28,780
Unassigned	5,240	12,470	17,710
Allocation Percent	29.6%	70.4%	100%
Waste Acceptance, Storage & Transportation	**1,310**	**4,760**	**6,070**
Assigned	1,140	4,130	5,270
Unassigned	170	630	800
Allocation Percent	21.6%	78.4%	100%
Program – Unassigned	**1,230**	**3,100**	**4,330**
Allocation Percent	28.4%	71.6%	100%
Total	**16,300**	**40,590**	**56,890**
Aggregate Allocation Percent	28.7%	71.3%	100%

NOTE: Totals may not add or compare with other totals due to independent rounding.

The cost allocation decomposes system components to a meaningful level that allows an assignment of a share methodology. The percentage used to calculate the shared cost account is called a cost-sharing factor. Cost accounts are grouped into one of the following categories:

1. **Assignable direct costs** are solely for the disposal of DOE SNF and HLW, or commercial SNF and HLW, and are allocated in total to their respective cost share account.

2. **Assignable common variable costs** are allocated among the civilian SNF and HLW and government-managed nuclear material by applying cost-sharing factors, piece count, and areal dispersion, a measure of below ground space requirements, to the specific waste generator cost accounts. Sharing costs by a piece-count factor is based on the number of WPs emplaced. Sharing costs by areal dispersion is based on the repository disposal area required for DOE SNF and HLW, or commercial SNF and HLW disposal divided by the total disposal area.

3. **Common unassigned costs** are the remaining costs that cannot be either directly allocated or allocated on cost-sharing factors. These unassigned costs are allocated by deriving cost-sharing factors based on the ratio of assignable DOE SNF and HLW, or commercial SNF and HLW costs to the total assignable costs for assignable repository costs, assignable transportation costs, or assignable D&E costs.

8. REFERENCES

8.1 DOCUMENTS CITED

Barrett, L. H. 1999. "Office of Civilian Radioactive Waste Management's FY 2001 Corporate Review Budget Request." Memorandum from L.H. Barrett (OCRWM) to Mike Telson, Chief Financial Officer (CR-1), June 9, 1999. ACC: MOV.19990901.0001.

Cohon, J. L. 1998. "Transmittal of Feedback to OCRWM Following the Nuclear Waste Technical Review Board Meeting, Three Panel Meetings and one Field Trip." Letter from J.L. Cohon (Nuclear Waste Technical Review Board) to L.H. Barrett (OCRWM), January 12, 1998. ACC: HQO.1998603.0007.

CRWMS M&O (Civilian Radioactive Waste Management System Management and Operating Contractor) 1998a. *Basis for the VA and TSLCC Cost Estimate Operational Waste Stream*. A00000000-01717-1701-00002. Vienna, Virginia: CRWMS M&O. ACC: MOV.19980622.0021.

CRWMS M&O 1998b. *Waste Acceptance, Storage and Transportation (WAST) – Cost Estimate Assumptions Document*. A10000000-01717-1701-00001 REV 01. Vienna, Virginia: CRWMS M&O. ACC: MOV.19981130.0001.

CRWMS M&O 1999a. *Cost Escalation and Interest Rates for 1999*. A00000000-01717-1400-0001 REV 01. Vienna, Virginia: CRWMS M&O. ACC: MOV.19990526.0036.

CRWMS M&O 1999b. *Historical Status of Obligational Authority Fiscal Years 1983-1998* A00000000-01717-5708-00001 REV 01. Vienna, Virginia: CRWMS M&O. ACC: MOV.19990901.0003.

CRWMS M&O 1999c. *License Application Design Selection Report*. B00000000-01717-4600-00112 REV 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990528.0303.

CRWMS M&O 1999d. *Systems Engineering & Integration Department Weekly Activity Report*. September 17, 1999. Vienna, Virginia: CRWMS M&O. ACC: MOV.19990920.0037.

CRWMS M&O 1999e. *Technical Manual for the CRWMS Analysis and Visually Interactive Model*. Version 2.0. 0074-TM-2.0 REV 00. Vienna, Virginia: CRWMS M&O. ACC: MOV.19990322.0002.

DOE (U.S. Department of Energy) 1995a. *Acceptance Priority Ranking and Annual Capacity Report*. DOE/RW-0457. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOV.19960910.0021.

DOE 1995b. *The Nuclear Waste Policy Act, as Amended with Appropriations Acts Appended*. DOE/RW-0438 REV 01. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: HQO.19950124.0001.

DOE 1997. *OCRWM Program Baseline Change Control Procedure*. DOE/RW-0409 REV 02 DCN 01. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOV.19970910.0007.

DOE 1998a. *Analysis of the Total System Life Cycle Cost of the Civilian Radioactive Waste Management Program*. DOE/RW-0510. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: HQO.19980901.0001.

DOE 1998b. *Viability Assessment of a Repository at Yucca Mountain*. DOE/RW-0508. Five volumes. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. MOL. 19981007.0027, .0028, .0029, .0030, .0031, .0032.

DOE 1999a. *Civilian Radioactive Waste Management System Requirements Document*. DOE/RW-0406 REV 05. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: HQO.19990112.0001.

DOE 1999b. *OCRWM Waste Acceptance, Storage and Transportation Project Cost and Schedule Baseline*. DOE/RW-0469 REV 05. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: HQO.19990607.0001.

DOE 1999c. *Office of Civilian Radioactive Waste Management Program Cost and Schedule Baseline*. DOE/RW-0253 REV 06 DCN 03. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: HQO.19990708.0001.

DOE 1999d. "YMP Level II Change Request (CR) Status Report." Las Vegas, Nevada. U.S. Department of Energy, Office of Civilian Radioactive Waste Management. Accessed September 3, 1999. TIC: 245411
http/intranet.ymp.gov/opc/cr_status.htm.

Dyer, J. R. 1998. *Fiscal Year (FY) 1999 Guidance for Updating the Multi-Year Plan.* Letter from J.R. Dyer (DOE) to D.R. Wilkins (CRWMS M&O). OPC:JRS-1469. May 1, 1998. ACC: MOL.19980803.0509; MOL.19980803.0592.

8.2 CODES, STANDARDS, REGULATIONS, AND PROCEDURES

10 CFR (*Code of Federal Regulations)* 60. Energy: Disposal of High-Level Radioactive Wastes in Geologic Repositories. Readily available.

10 CFR 961. Energy: Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste. Revised as of January 1, 1998. TIC: 231403.

52 FR (*Federal Register*) 31508. Energy: Civilian Radioactive Waste Management; Calculating Nuclear Waste Fund Disposal Fees for Department of Energy Defense Program Waste. Readily available.

YAP-30.61, REV 02, ICN 0. Integrated Planning, Change Request Preparation, and Baseline Change Implementation. Las Vegas, Nevada. CRWMS M&O. ACC: MOL.19990712.0122.

APPENDIX A

1999 TOTAL SYSTEM LIFE CYCLE COST ESTIMATE SUMMARY

INTENTIONALLY LEFT BLANK

1999 TOTAL SYSTEM LIFE CYCLE COST ESTIMATE SUMMARY

Table A-1 provides the 1999 TSLCC estimate in constant 1999 dollars. The total estimated future cost to complete the program is $43.9 Billion for Case 1 and $49.2 Billion for Case 2. A total of $6.3 Billion was spent through 1999 in YOE dollars. Escalating historical expenditures to 1999 constant year dollars ($7.7 Billion), plus the cost to complete of $43.9 Billion for Case 1 and $49.2 Billion for Case 2, results in a estimate for the CRWMS of $51.6 Billion for Case 1 and $56.9 Billion for Case 2.

Table A-1. 1999 TSLCC Estimate Summary (in Millions of 1999$)

Cost Element	Historical (1983-1999)	Case 1 Future Costs	Case 1 Total Costs	Case 2 Future Costs	Case 2 Total Costs
Monitored Geologic Repository	**5,340**	**32,130**	**37,470**	**36,590**	**41,930**
Development & Evaluation (1983-2002)	**5,340**	**740**	**6,080**	**740**	**6,080**
Single Repository (MGR) (Yucca Mt. Site)	3,610	740	4,350	740	4,350
Other First Repository Characterization	1,610	0	1,610	0	1,610
Second Repository	120	0	120	0	120
Surface Facilities	**0**	**6,720**	**6,720**	**7,300**	**7,300**
Licensing	0	160	160	160	160
Pre-Emplacement Construction	0	1,320	1,330	1,320	1,330
Emplacement Operations	0	4,640	4,640	4,640	4,640
Monitoring Operations	0	440	440	1,020	1,030
Closure & Decommissioning	0	160	160	160	160
Subsurface Facilities	**0**	**7,510**	**7,510**	**10,000**	**10,000**
Licensing	0	110	110	110	110
Pre-Emplacement Construction	0	1,160	1,160	1,160	1,160
Emplacement Operations	0	4,360	4,360	4,360	4,360
Monitoring Operations	0	640	640	3,130	3,130
Closure & Decommissioning	0	1,240	1,240	1,240	1,240
Waste Package & Drip Shield Fabrication	**0**	**13,510**	**13,510**	**13,530**	**13,530**
Licensing	0	39	39	39	39
Pre-Emplacement Construction	0	83	83	83	83
Emplacement Operations	0	7,120	7,120	7,120	7,120
Monitoring Operations	0	790	790	810	810
Closure & Decommissioning	0	5,480	5,480	5,480	5,480
Performance Confirmation	**0**	**1,450**	**1,450**	**2,370**	**2,370**
Licensing	0	110	110	110	110
Pre-Emplacement Construction	0	190	190	190	190
Emplacement Operations	0	890	890	890	890
Monitoring Operations	0	260	260	1,150	1,150
Closure & Decommissioning	0	6	6	21	21
Regulatory, Infrastructure, and Mgmt. Services	**0**	**2,200**	**2,200**	**2,650**	**2,650**
Licensing	0	340	340	340	340
Pre-Emplacement Construction	0	470	470	470	470
Emplacement Operations	0	1,020	1,020	1,020	1,020
Monitoring Operations	0	190	190	640	640
Closure & Decommissioning	0	180	180	180	180
Waste Acceptance, Storage & Transportation	**490**	**5,140**	**5,630**	**5,140**	**5,630**
Development & Evaluation (1983-2005)	**490**	**36**	**530**	**36**	**530**
Storage (no ISF)	210	0	210	0	210
Transportation	210	22	230	22	230
Waste Acceptance	24	7	31	7	31
MPC Project	38	0	38	0	38
Project Management and Integration	9	7	16	7	16
Mobilization and Acquisition (2005-2010)	**0**	**110**	**110**	**110**	**110**
National Transportation	0	91	91	91	91
Waste Acceptance	0	10	10	10	10
Project Management and Integration	0	10	10	10	10
Operations (2010-2042)	**0**	**4,990**	**4,990**	**4,990**	**4,990**
National Transportation	0	4,930	4,930	4,930	4,930
Waste Acceptance	0	57	57	57	57
Nevada Transportation	**0**	**790**	**790**	**790**	**790**
Engineering & Construction	0	710	710	710	710
Operations	0	80	80	80	80
Program Integration	**1,590**	**2,130**	**3,720**	**2,610**	**4,200**
Program Management and Administration	**1,290**	**1,810**	**3,100**	**2,210**	**3,500**
Quality Assurance	110	556	670	556	670
Program Management and Integration	1,010	1,050	2,060	1,370	2,380
Human Resources & Administration	170	208	380	281	450
Non-OCRWM NWF Costs	**300**	**320**	**620**	**400**	**700**
Nuclear Regulatory Commission	260	290	550	370	630
Nuclear Waste Technical Review Board	25	27	52	27	52
Nuclear Waste Negotiator	10	0	10	0	10
Institutional Costs	**230**	**3,730**	**3,960**	**4,110**	**4,340**
Payments Equal-To-Taxes	44	2,740	2,780	3,030	3,070
Benefits	0	500	500	590	590
180(c) Assistance	1	460	460	460	460
Financial Assistance	180	25	210	25	210
TOTAL CRWMS COST	**7,650**	**43,920**	**51,570**	**49,240**	**56,890**

NOTE: Values greater than $100M have been rounded to the nearest $10M.

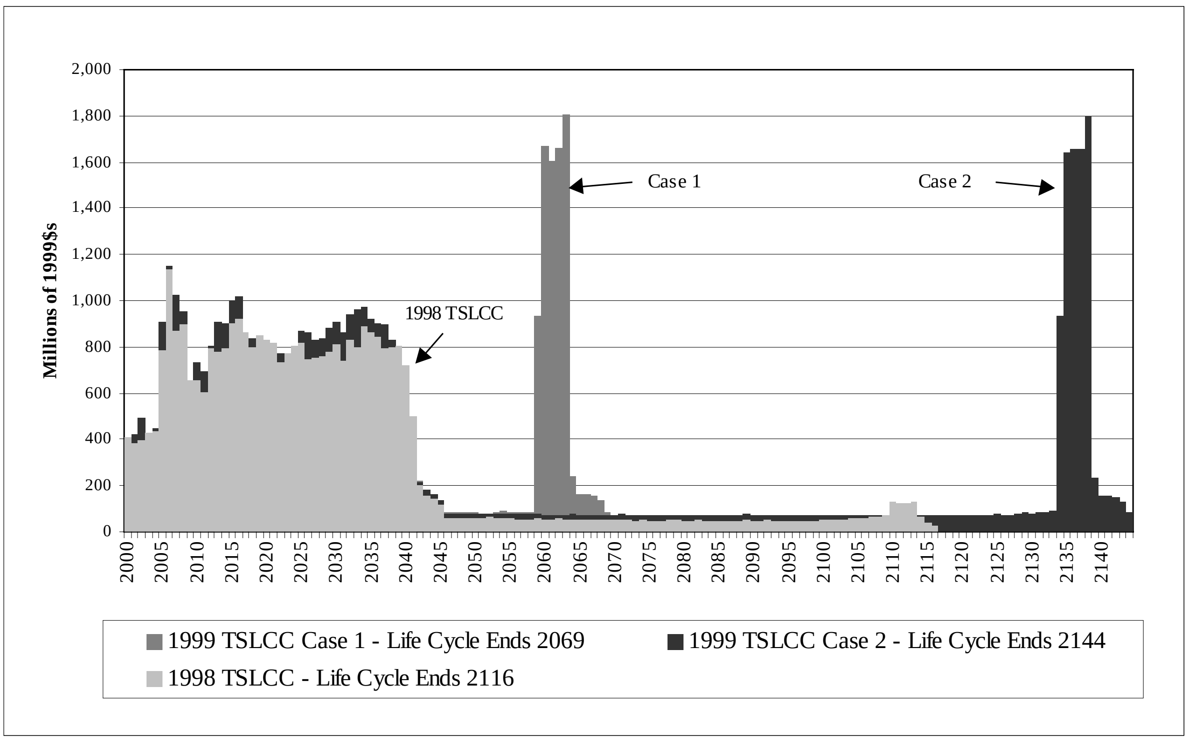
APPENDIX B

COMPARISON WITH 1998 TOTAL SYSTEM LIFE CYCLE COST

INTENTIONALLY LEFT BLANK

COMPARISON WITH 1998 TOTAL SYSTEM LIFE CYCLE COST

This appendix provides a comparison of the results of the current TSLCC estimate with the 1998 TSLCC estimate (DOE 1998a). The current estimate of $51.6 Billion for Case 1 and $56.9 Billion for Case 2, in constant 1999 dollars, compares with the 1998 TSLCC estimate of $44.4 Billion, escalated to 1999 dollars. The 1998 TSLCC assumed repository closure after 100 years from the start of emplacement. Cases 1 and 2 in this update cover different time periods. To facilitate a clear crosswalk between the estimates, Section B.1, Figure B-1 and Table B-1 provide a comparison of the 1998 TSLCC with a 1999 TSLCC estimate that has been adjusted to a comparable 100-year operating period. Table B-1 provides deltas between the 1998 and 1999 TSLCC estimates for impact of technical scope changes less the change in the operating period. Tables B-2 and B-3 provide a summary comparison of the results of the 1998 TSLCC estimate with the Case 1 and Case 2 TSLCC estimates, respectively, to show the combined effect of technical scope changes and the changes in the operating period. Figure B-1 shows cash a flow comparison of Case 1, Case 2 and the 1998 TSLCC.



Note: Costs for Case 1 and Case 2 are approximately equal for the fiscal years 2000 through 2050.

Figure B-1. Cash Flow Comparison of 1998 TSLCC with Case 1 and Case 2

B.1 SUMMARY COST COMPARISON WITH 1998 TSLCC

This section presents a comparison of the 1998 TSLCC (DOE 1998a) to a TSLCC estimate that includes the adoption of the EDA II design basis from the LADS Report (CRWMS M&O 1999c), and has a length similar to that of the operating period, with closure beginning 100 years after the start of emplacement. This comparison was accomplished by using the Case 2 annual data and subtracting 25 years from the monitoring phase. The changes that caused costs to increase for this analysis are the inclusion of drip shields, the lower areal mass loading that requires excavation into the characterized lower block, backfill of the emplacement drifts, and increased pool capacity of the surface facility for blending of fuel assemblies. The changes that caused costs to decrease for this analysis are the re-evaluation of the transportation cask fleet types and cost basis.

For this analysis, with the 1999 TSLCC having a 100-year operating period, the estimate increased by $10.7 Billion in 1999 dollars, or 24.2 percent. Repository and Institutional costs increased by $11.6 Billion, which was offset by a reduction of $0.9 Billion in WAST costs. Of the $10.8 Billion increase in Repository costs, $7.5 Billion was attributable to WP and drip shield fabrication costs, $3.0 Billion for subsurface facilities, and $0.6 Billion for D&E, RIMS, and surface facility costs. The Repository cost increase was offset by a decrease of $0.3 Billion in PC costs.

Table B-1. Comparison of 1998 and 1999 TSLCC for 100 Years of Monitoring (in Millions of 1999$)

Cost Element	TSLCC 1998		TSLCC 1999	Delta	
	1998 $	1999 $	1999 $	1999 $	
Monitored Geologic Repository Costs	**29,120**	**29,600**	**40,440**	**10,840**	
Development & Evaluation (1983-2002) Costs	**5,900**	**6,020**	**6,080**	**60**	
Single Repository (MGR) (Yucca Mountain Site)	4,200	4,280	4,350	70	
Other First Repository Characterization	1,590	1,620	1,610	(10)	
Second Repository	110	120	120	0	
Surface Facilities	**6,580**	**6,680**	**7,110**	**430**	
Licensing	150	150	160	10	
Pre-Emplacement Construction	1,180	1,200	1,330	130	[a]
Emplacement Operations	4,320	4,390	4,640	250	[a]
Monitoring Operations	800	810	830	20	[a]
Closure & Decommissioning	130	130	160	30	[a]
Subsurface Facilities	**6,020**	**6,110**	**9,160**	**3,050**	
Licensing	90	94	110	16	
Pre-Emplacement Construction	980	990	1,160	170	[a]
Emplacement Operations	3,660	3,720	4,360	640	[a]
Monitoring Operations	1,080	1,100	2,290	1,190	[a]
Closure & Decommissioning	210	210	1,240	1,030	[a]
Waste Package & Drip Shield Fabrication	**5,950**	**6,040**	**13,520**	**7,480**	
Licensing	40	39	39	0	
Pre-Emplacement Construction	50	53	83	30	
Emplacement Operations	5,840	5,930	7,120	1,190	[a]
Monitoring Operations	20	18	800	780	[a]
Closure & Decommissioning	0	0	5,480	5,480	[a]
Performance Confirmation	**2,320**	**2,350**	**2,080**	**(270)**	
Licensing	130	130	110	(20)	
Pre-Emplacement Construction	240	240	190	(50)	[a]
Emplacement Operations	1,080	1,100	890	(210)	[a]
Monitoring Operations	870	880	860	(20)	[a]
Closure & Decommissioning	0	0	21	21	[a]
Regulatory, Infrastructure & Management Services	**2,350**	**2,400**	**2,490**	**90**	
Licensing	350	360	340	(20)	
Pre-Emplacement Construction	500	510	470	(40)	
Emplacement Operations	990	1,010	1,020	10	
Monitoring Operations	450	460	490	30	
Closure & Decommissioning	60	67	180	110	[a]
Waste Acceptance, Storage & Transportation	**6,390**	**6,490**	**5,630**	**(860)**	
Development & Evaluation (1983-2005) Costs	**530**	**540**	**530**	**(10)**	
Storage (no ISF Facility)	200	210	210	0	
Transportation	240	240	230	(10)	
Waste Acceptance	30	29	31	2	
MPC Project	40	38	38	0	
Project Management and Integration	20	16	16	0	
Mobilization and Acquisition (2005-2010)	**140**	**140**	**110**	**(30)**	
National Transportation	120	120	91	(29)	
Waste Acceptance	10	10	10	0	
Project Management and Integration	10	10	10	0	
Operations (2010-2042)	**5,720**	**5,810**	**4,990**	**(820)**	
National Transportation	5,660	5,750	4,930	(820)	
Waste Acceptance	60	57	57	0	
	0	0	0	0	
Nevada Transportation	**790**	**800**	**790**	**(10)**	
Engineering & Construction	700	710	710	0	
Operations	90	90	80	(10)	
Program Integration	**3,990**	**4,040**	**4,050**	**10**	
Program Management and Administration	**3,330**	**3,380**	**3,380**	**0**	
Quality Assurance	670	680	670	(10)	
Program Management and Integration	2,230	2,260	2,280	20	
Human Resources & Administration	430	440	440	0	
Non-OCRWM NWF Costs	**660**	**660**	**670**	**10**	
Nuclear Regulatory Commission	600	600	600	0	
Nuclear Waste Technical Review Board	50	51	52	1	
Nuclear Waste Negotiator	10	10	10	0	
Institutional Costs	**3,400**	**3,460**	**4,230**	**770**	
Payments Equal-To-Taxes (PETT)	2,280	2,320	2,980	660	[a]
Benefits	470	480	570	90	
180(c) Assistance	450	460	460	0	
Financial Assistance	200	200	210	10	
TOTAL CRWMS COST	**43,690**	**44,410**	**55,140**	**10,730**	

[a] Signifies a scope change to the category. Other deltas are due to rounding and changes in forecasted costs.

B.2 CASE 1 SUMMARY COST COMPARISON WITH 1998 TSLCC

The significant program change for Case 1 since the 1998 TSLCC (DOE 1998a) is the adoption of the EDA II design basis from the LADS Report (CRWMS M&O 1999c). The changes that caused costs to increase are the inclusion of drip shields, the lower thermal load that requires excavation into the characterized lower block, backfill of the emplacement drifts, and increased pool capacity of the surface facility for blending of fuel assemblies. The changes that caused costs to decrease for Case 1 are the reduction in the operating period from 100 years to 50 years from the start of emplacement, and the re-evaluation of the transportation cask fleet types and cost basis. For Case 1, the TSLCC estimate increased by $7.2 Billion in 1999 dollars, or 16.1 percent. Repository and institutional costs increased by $8.4 Billion, which was offset by a reduction of $1.2 Billion in WAST and Program Integration costs.

B.2.1 Monitored Geologic Repository

The cost of the repository increased by $7.9 Billion from the 1998 TSLCC (DOE 1998a) estimate for Case 1. This estimate includes increases of $7.5 Billion in WP and drip shield fabrication costs, $1.4 Billion in subsurface facility costs, $0.04 Billion in surface facility costs, and $0.06 Billion in D&E costs. There is a net decrease of $1.1 Billion in the combined repository performance confirmation and RIMS categories due to reduced workscope for performance confirmation and a decreased operating period.

Overall costs for WPs increased by $7.5 Billion primarily due to the inclusion of titanium drip shields in this cost category. Drip shield fabrication costs added $6.3 Billion to this category. Of the $6.3 Billion, $2.7 Billion was added to the end of the monitoring phase since lead-time is required to procure and fabricate the drip shields in time for their emplacement during the closure and decommissioning phase, before backfilling can begin. WP fabrication costs increased by $0.4 Billion due to an increase in the unit costs for material changes in the EDA II design. The WP fabrication costs would have been higher, but blending reduced the quantity of WPs by approximately 250 by shifting 500 small PWR WPs to large PWR WPs. The cost for WP supports increased by $0.8 Billion due to the change in material from concrete to Alloy-22 in the EDA II design.

Subsurface costs increased overall by $1.4 Billion after an increase of $2.6 Billion due to additional access excavation, ventilation, and backfill, and a reduction of $1.2 Billion for lower emplacement drift excavation and monitoring phase costs. Additional accesses to the lower block to accommodate the EDA II for a lower areal mass loading increased costs by $0.8 Billion. Ventilation at 10 cubic meters per second for the 50 years from the beginning of emplacement increased costs by approximately $1.2 Billion. Of the $1.2 Billion for ventilation, $0.1 Billion is for increased ventilation shafts, $0.7 Billion for subsurface operations that includes the added costs for vent fan purchase, replacement, and operations, and the remainder $0.4 Billion is for increased costs for support facilities and management. Backfill of the emplacement drifts with quartz sand increased the subsurface costs by $0.6 Billion. The EDA II changed the emplacement drifts loading from point-loaded to line-loaded, and changed the drift lining from concrete to steel. This reduced the drift excavation costs by $0.4 Billion. The reduction in the monitoring period by 50 years in Case 1 reduced subsurface costs by $0.8 Billion dollars.

Overall, the repository surface facility costs increased $0.04 Billion after increases for additional pool storage and operations costs, and a reduction for decreased monitoring. The surface facility costs increase $0.13 Billion for additional pool storage to accomplish the fuel blending requirements in EDA II. Surface facility operations increased by $0.25 Billion for additional activities such as fuel blending and maintenance of the solar power system. Closure and decommissioning costs increased by $0.03 Billion. These cost increases were offset by a decrease of $0.37 Billion for the reduction in the monitoring period.

Net costs for D&E increased by $0.06 Billion from the 1998 TSLCC (DOE 1998a). This increase resulted from the actual FY 1998 costs being $0.07 Billion higher than projected in the previous estimate. The decrease of $0.01 Billion in Other First Repository Costs was due to accounting adjustments in prior year costs.

The net RIMS costs decreased by $0.2 Billion from the 1998 TSLCC. The reduction in the licensing, construction, and monitoring phase reduced RIMS costs by $0.3 Billion. This decrease was offset by an increase of $0.1 Billion of cost during the emplacement, and closure and decommissioning phase to support the increased activity for installing drip shields and backfill.

The overall estimate for PC decreased by $0.9 Billion. The reduction in the monitoring phase reduced PC costs by $0.6 Billion. Costs for PC decreased an additional $0.3 Billion due to reduced work scope for the EDA II in the licensing, construction, and emplacement phases.

B.2.2 Waste Acceptance, Storage and Transportation

The change in the WAST cost estimate is a decrease of $0.9 Billion in 1999 dollars. The principal differences between the 1999 and 1998 WAST costs are the updated cask fleet and waste site modal assumptions. The following changes in cask fleet assumptions were made for 1999:

1. Use of a new transportation cask "reference" design for small single-purpose (SP) and high-heat casks. This cask has a capacity of 12 PWR or 32 BWR assemblies.

2. Use of specific dual-purpose (DP) cask designs for plants that have committed to these casks.

3. Change in the cask capacity for South Texas SNF from 12 to 17 assemblies.

4. Increase in the capacity of the large BWR SP and "generic" DP casks from 61 to 68 assemblies; decrease in the large PWR SP cask capacity from 26 to 24 assemblies (reflects a revised "reference" design for the large "generic" casks).

5. Substitution of the NAC-LWT for the NLI-1/2 as the high-heat truck cask (no change in capacity).

6. Inclusion of existing DOE-owned West Valley SNF casks.

7. Reduction in cask capacity for Big Rock Point SNF from 74 to 64 assemblies (there are 74 slots in the basket, but only 64 can carry fuel assemblies).

The following changes in waste site modal assumptions were made for the 1999 TSLCC:

1. All reactors that are projected to need (for pool overflow or to unload pool) onsite dry storage in the future (and have not already committed to a specific storage system) will utilize "generic" large rail (24 PWR/68 BWR) DP storage/transportation systems.

2. Reactors that have committed to a specific DP or SP system for storage will use that system for all onsite storage.

3. Three shutdown reactors that were previously identified as using truck casks have announced plans to offload their fuel into large DP storage systems. Therefore, these plants are assumed to transport all of their fuel in DP transportation casks.

4. Sites that utilize dry storage are assumed to transport all fuel taken from storage in DP transportation casks. Fuel taken from pools is assumed to be transported in SP casks (truck or rail).

Other changes in assumptions for the 1999 WAST calculations are as follows:

1. The commercial SNF acceptance rate in FY 2010 (400 MTHM/year) is adjusted for the actual projected start date (4/1/2010). This results in an actual commercial SNF acceptance in FY 2010 of 200 MTHM.

2. The defense waste (HLW and DOE SNF) sites (including WV) are combined into one pseudo "region" for cask fleet calculation purposes. This allows transportation resources (casks, etc.) to be shared among all the sites, which is consistent with the assumption that all HLW and DOE SNF is transported by a single RSC.

3. The start and end dates of the RSC operating "Phases" are adjusted to reflect the latest WAST Project Cost and Schedule Baseline (DOE 1999b).

4. RSC costs for supplemental community and out reach support during the first 10 years of Phase C are reduced by cutting the cost to one-half in the 6th year, and then reducing the cost linearly to zero by the 10th year.

B.2.3 Nevada Transportation

The estimate for engineering and construction of a branch rail line in Nevada has not changed in constant 1999 dollars from the 1998 TSLCC (DOE 1998a) estimate. The operations estimate was decreased slightly after re-evaluating the cost basis for the estimate.

B.2.4 Program Integration

Program Integration costs decreased by $0.3 Million. Program Integration scope was not re-evaluated for this estimate, and the decrease is due to the reduction in the monitoring phase for Case 1.

B.2.5 Institutional Costs

PETT costs have increased by $0.46 Billion in constant 1999 dollars for the 1999 TSLCC. This increase reflects the net effect of two changes in PETT costs from the 1998 TSLCC (DOE 1998a). A reduction of $0.2 Billion of PETT costs was attributable to the reduced monitoring phase. However, PETT costs increased by $0.66 Billion due to an increase in sales and use tax payment for increased capital expenditures. Capital expenditures primarily increased from the inclusion of titanium drip shields, and increased WP costs.

Benefit costs had a net increase of $20 Million due to the change in forecasted escalation rates. The forecasted escalation rates for the 1999 TSLCC decreased by approximately 0.5 percent, lowering the discount factor that is applied to future Benefit payments for conversion into constant 1999 dollars. A reduction of $50 Million of Benefit payments was saved due to the reduced monitoring phase.

The estimated cost for 180(c) Assistance has not changed in constant 1999 dollars from the previous TSLCC estimate. The $0.01 Billion increase in the life cycle cost for Financial Assistance can be attributed to a small change in cost that pushed the total across the $10 Million rounding threshold.

B.2.6 Change to Monitoring Phase

The 1998 TSLCC assumed that closure and decommissioning activities would begin in 2110, 100 years after the beginning of emplacement. The current TSLCC estimate for Case 1 assumes a reduced monitoring phase with closure and decommissioning beginning in 2060, 50 years after the beginning of emplacement. The current TSLCC assumes closure and decommissioning activities take three years more than in the previous estimate to allow for drip shield emplacement and backfill. The reduction of 50 years in the monitoring phase reduced the repository costs by $2.6 Billion in constant 1999 dollars. These cost reductions are distributed over most elements of cost, with the exception of transportation-related costs.

B.2.7 Change in Cost Share Allocation

Changes in program scope and in the TSLCC estimate resulted in changes to the civilian and DOE cost shares for Case 1. The civilian share allocation decreased from 74.9 percent to 71.8 percent, and the share for DOE SNF and HLW increased from 24.7 percent to 28.2 percent of total costs. The changes in cost shares result primarily from the decrease in the total quantity of commercial waste packages to be emplaced, due to blending commercial SNF into larger disposal containers, and the change from point-loading the emplacement drifts to line-loading. These two system changes lead to a modification of the piece-count and areal dispersion factors used for calculating the assignable common variable costs. The civilian cost share would have decreased additionally by 0.3 percent, but the WV cost share was combined with the civilian share.

Table B-2. Comparison of 1998 and 1999 TSLCC for Case 1 (in Millions of 1999$)

Cost Element	TSLCC 1998		TSLCC 1999	Delta	
	1998 $	1999 $	1999 $	1999 $	
Monitored Geologic Repository Costs	**29,120**	**29,600**	**37,470**	**7,870**	
Development & Evaluation (1983-2002) Costs	**5,900**	**6,020**	**6,080**	**60**	
Single Repository (MGR) (Yucca Mountain Site)	4,200	4,280	4,350	70	
Other First Repository Characterization	1,590	1,620	1,610	(10)	
Second Repository	110	120	120	0	
Surface Facilities	**6,580**	**6,680**	**6,720**	**40**	
Licensing	150	150	160	10	
Pre-Emplacement Construction	1,180	1,200	1,320	120	a
Emplacement Operations	4,320	4,390	4,640	250	a
Monitoring Operations	800	810	440	(370)	
Closure & Decommissioning	130	130	160	30	a
Subsurface Facilities	**6,020**	**6,110**	**7,510**	**1,400**	
Licensing	90	94	110	16	
Pre-Emplacement Construction	980	990	1,160	170	a
Emplacement Operations	3,660	3,720	4,360	640	a
Monitoring Operations	1,080	1,100	640	(460)	a
Closure & Decommissioning	210	210	1,240	1,030	a
Waste Package & Drip Shield Fabrication	**5,950**	**6,040**	**13,510**	**7,470**	
Licensing	40	39	39	0	
Pre-Emplacement Construction	50	53	83	30	
Emplacement Operations	5,840	5,930	7,120	1,190	a
Monitoring Operations	20	18	790	770	a
Closure & Decommissioning	0	0	5,480	5,480	a
Performance Confirmation	**2,320**	**2,350**	**1,450**	**(900)**	
Licensing	130	130	110	(20)	
Pre-Emplacement Construction	240	240	190	(50)	a
Emplacement Operations	1,080	1,100	890	(210)	a
Monitoring Operations	870	880	260	(620)	
Closure & Decommissioning	0	0	6	6	a
Regulatory, Infrastructure & Management Services	**2,350**	**2,400**	**2,200**	**(200)**	
Licensing	350	360	340	(20)	
Pre-Emplacement Construction	500	510	470	(40)	
Emplacement Operations	990	1,010	1,020	10	
Monitoring Operations	450	460	190	(270)	
Closure & Decommissioning	60	67	180	110	a
Waste Acceptance, Storage & Transportation	**6,390**	**6,490**	**5,630**	**(860)**	
Development & Evaluation (1983-2005) Costs	**530**	**540**	**530**	**(10)**	
Storage (no ISF Facility)	200	210	210	0	
Transportation	240	240	230	(10)	
Waste Acceptance	30	29	31	2	
MPC Project	40	38	38	0	
Project Management and Integration	20	16	16	0	
Mobilization and Acquisition (2005-2010)	**140**	**140**	**110**	**(30)**	
National Transportation	120	120	91	(29)	
Waste Acceptance	10	10	10	0	
Project Management and Integration	10	10	10	0	
Operations (2010-2042)	**5,720**	**5,810**	**4,990**	**(820)**	
National Transportation	5,660	5,750	4,930	(820)	
Waste Acceptance	60	57	57	0	
Nevada Transportation	**790**	**800**	**790**	**(10)**	
Engineering & Construction	700	710	710	0	
Operations	90	90	80	(10)	
Program Integration	**3,990**	**4,040**	**3,720**	**(320)**	
Program Management and Administration	**3,330**	**3,380**	**3,100**	**(280)**	
Quality Assurance	670	680	670	(10)	
Program Management and Integration	2,230	2,260	2,060	(200)	
Human Resources & Administration	430	440	380	(60)	
Non-OCRWM NWF Costs	**660**	**660**	**620**	**(40)**	
Nuclear Regulatory Commission	600	600	550	(50)	
Nuclear Waste Technical Review Board	50	51	52	1	
Nuclear Waste Negotiator	10	10	10	0	
Institutional Costs	**3,400**	**3,460**	**3,960**	**500**	
Payments Equal to Taxes (PETT)	2,280	2,320	2,780	460	a
Benefits	470	480	500	20	
180 (c) Assistance	450	460	460	0	
Financial Assistance	200	200	210	10	
TOTAL CRWMS COST	**43,690**	**44,410**	**51,570**	**7,160**	

[a] Signifies a scope change to the category. Other deltas are due to the changes in the monitoring length, forecasts, and rounding.

B.3 CASE 2 SUMMARY COST COMPARISON WITH 1998 TSLCC

The significant program change for Case 2 since the 1998 TSLCC (DOE 1998a)is the adoption of the EDA II design basis from the LADS Report (CRWMS M&O 1999c). The changes that caused costs to increase are the inclusion of drip shields, the lower thermal load that requires excavation into the characterized lower block, backfill of the emplacement drifts, the increased pool capacity of the surface facility for blending of fuel assemblies, and the increase of 25 years in the monitoring phase. The change that caused costs to decrease for Case 2 is the reevaluation of the transportation cask fleet types and cost basis. For Case 2, the TSLCC estimate increased by $12.5 Billion in 1999 dollars, or 28.1 percent. Repository and PI&I costs increased by $13.4 Billion, which was offset by a reduction of $0.9 Billion in WAST costs.

B.3.1 Monitored Geologic Repository

The cost of the repository increased by $12.3 Billion from the 1998 TSLCC (DOE 1998a) estimate for Case 2. This estimate includes increases of $7.5 Billion in WP and drip shield fabrication costs, $3.9 Billion in subsurface facility costs, $0.6 Billion in surface facility costs, $0.2 Billion in RIMS costs, and $0.1 Billion in D&E costs.

Overall costs for WPs increased by $7.5 Billion primarily due to the inclusion of titanium drip shields in this cost category. Drip shield fabrication costs added $6.3 Billion to this category. Of the $6.3 Billion, $2.7 Billion was added to the end of the monitoring phase since lead time is required to procure and fabricate the drip shields in time for their emplacement during the closure and decommissioning phase, before backfilling can begin. WP fabrication costs increased by $0.4 Billion due to an increase in the unit costs for material changes in the EDA II design. The WP fabrication costs would have been higher, but blending reduced the quantity of WPs by approximately 250 by shifting 500 small PWRs to large PWRs. The cost for WP supports increased by $0.8 Billion due to the change in material from concrete to Alloy-22 in the EDA II design.

Subsurface costs increased by $3.9 Billion due to additional access excavation to the lower block, an increased ventilation rate, backfill, and an additional 25 years of monitoring. Additional accesses to the lower block to accommodate the EDA II for a lower areal mass loading increased costs by $0.8 Billion. Ventilation at 10 cubic meters per second for the 125 years from the beginning of emplacement increased costs by approximately $2.9 Billion. Of the $2.9 Billion for ventilation, $0.1 Billion is for increased ventilation shafts, $2.1 Billion for subsurface operations (which includes the added costs for vent fan purchase, replacement, and operations), and the remainder of $0.7 Billion is for increased costs for support facilities and management. Backfill of the emplacement drifts with quartz sand increased the subsurface costs by $0.6 Billion. The EDA II changed the loading of the emplacement drifts from point-load to line-load, and changed the drift lining from concrete to steel. This reduced drift excavation costs by $0.4 Billion.

Overall, the repository surface facility costs increased $0.6 Billion after increases for additional pool storage and operations costs, and for increased monitoring. The surface facility costs increases $0.14 Billion for additional pool storage to accomplish the fuel blending requirements in EDA II. Surface facility operations increased by $0.25 Billion for additional activities such as fuel blending and maintenance of the solar power system. The monitoring phase increase added

$0.2 Billion to the surface facility cost. Closure and decommissioning costs increased by $0.03 Billion.

Costs for D&E increased by $0.06 Billion from the 1998 TSLCC (DOE 1998a). This increase resulted from the actual FY 1998 costs being $70 Million higher than projected in the previous estimate. The decrease of $0.01 Billion in Other First Repository Costs was due to accounting adjustments in prior year costs.

The RIMS costs increased by $0.24 Billion from the 1998 TSLCC. A net decrease of $0.05 for the licensing, construction, and emplacement operations phases was offset with an increase in the monitoring phase of $0.18 Billion to RIMS costs. An increase of $0.11 Billion of costs during the closure and decommissioning phase was added to support the increased activity for installing drip shields and backfill.

The estimate for PC essentially remained the same. The increase in the monitoring phase increased PC costs by $0.3 Billion. This cost increase for PC was offset by a decreased of $0.3 Billion due to reduced work scope needed for the EDA II design.

B.3.2 Waste Acceptance, Storage and Transportation

The change in the WAST cost estimate is a decrease of $0.9 Billion in 1999 dollars. The principal differences between the 1999 and 1998 WAST costs are the updated cask fleet and waste site modal assumptions. For more details see Section B.2.2.

B.3.3 Nevada Transportation

The estimate for engineering and construction of a branch rail line in Nevada has not changed in constant 1999 dollars from the 1998 TSLCC estimate (DOE 1998a). The operations estimate was decreased slightly after re-evaluating the cost basis for the estimate.

B.3.4 Program Integration

Program Integration costs increased by $0.16 Million. Program Integration scope was not re-evaluated for this estimate, and the increase is due to the extra 25 years in the monitoring phase.

B.3.5 Institutional Costs

PETT costs have increased by $0.8 Billion in constant 1999 dollars for the 1999 TSLCC. This increase reflects the effect of two changes in PETT costs from the 1998 TSLCC (DOE 1998a). An increase of $0.1 Billion of PETT costs was attributable to the increased monitoring phase. PETT costs increased by $0.7 Billion due to an increase in sales and use tax payment for increased capital expenditures for drip shields and WP costs.

Benefit costs increased by $0.1 Billion due to the increased monitoring phase and the change in forecasted escalation rates. The forecasted escalation rates for the 1999 TSLCC decreased by approximately 0.5 percent, lowering the discount factor that is applied to future Benefit payments for conversion into constant 1999 dollars.

The estimated cost for 180(c) Assistance has not changed in constant 1999 dollars from the 1998 TSLCC estimate. The $0.01 Billion increase in the life cycle cost for Financial Assistance can be attributed to a small change in cost that pushed the total across the $10 Million rounding threshold.

B.3.6 Change to Monitoring Phase

The 1998 TSLCC assumed that closure and decommissioning activities would begin in 2110, 100 years after the beginning of emplacement. The current TSLCC estimate for Case 2 assumes an increased monitoring phase with closure and decommissioning beginning in 2135, 125 years after the beginning of emplacement. The current TSLCC assumes closure and decommissioning activities take three years more than in the previous estimate for drip shield emplacement and backfill. The increase of 25 years in the monitoring phase added $1.9 Billion in constant 1999 dollars to the repository costs. This additional cost is distributed over most elements of cost, with the exception of transportation-related costs.

B.3.7 Change in Cost Share Allocation

Changes in program scope and in the TSLCC estimate resulted in changes to the civilian, WV, and DOE cost shares for Case 2. The civilian share allocation decreased from 74.9 percent to 71.3 percent and the share for DOE SNF and HLW increased from 24.7 percent to 28.7 percent of total costs. The changes in cost shares result primarily from the decrease in the total quantity of commercial waste packages to be emplaced, due to blending commercial spent fuel into larger disposal containers, and the change from point-loading the emplacement drifts to line-loading. These two system changes lead to a modification of the piece count and areal dispersion factors used for calculating the assignable common variable costs. The civilian cost share would have decreased additionally by 0.3 percent, but the WV cost share was combined with the civilian share.

Table B-3. Comparison of 1998 and 1999 TSLCC for Case 2 (in Millions of 1999$)

Cost Element	TSLCC 1998		TSLCC 1999	Delta	
	1998 $	1999 $	1999 $	1999 $	
Monitored Geologic Repository Costs	**29,120**	**29,600**	**41,930**	**12,330**	
Development & Evaluation (1983-2002) Costs	**5,900**	**6,020**	**6,080**	**60**	
Single Repository (MGR) (Yucca Mountain Site)	4,200	4,280	4,350	70	
Other First Repository Characterization	1,590	1,620	1,610	(10)	
Second Repository	110	120	120	0	
Surface Facilities	**6,580**	**6,680**	**7,300**	**620**	
Licensing	150	150	160	10	
Pre-Emplacement Construction	1,180	1,200	1,320	120	a
Emplacement Operations	4,320	4,390	4,640	250	a
Monitoring Operations	800	810	1,020	210	
Closure & Decommissioning	130	130	160	30	a
Subsurface Facilities	**6,020**	**6,110**	**10,000**	**3,890**	
Licensing	90	94	110	16	
Pre-Emplacement Construction	980	990	1,160	170	a
Emplacement Operations	3,660	3,720	4,360	640	a
Monitoring Operations	1,080	1,100	3,130	2,030	a
Closure & Decommissioning	210	210	1,240	1,030	a
Waste Package & Drip Shield Fabrication	**5,950**	**6,040**	**13,530**	**7,490**	
Licensing	40	39	39	0	
Pre-Emplacement Construction	50	53	83	30	
Emplacement Operations	5,840	5,930	7,120	1,190	a
Monitoring Operations	20	18	810	790	a
Closure & Decommissioning	0	0	5,480	5,480	a
Performance Confirmation	**2,320**	**2,350**	**2,370**	**20**	
Licensing	130	130	110	(20)	
Pre-Emplacement Construction	240	240	190	(50)	a
Emplacement Operations	1,080	1,100	890	(210)	a
Monitoring Operations	870	880	1,150	270	
Closure & Decommissioning	0	0	21	21	a
Regulatory, Infrastructure & Management Services	**2,350**	**2,400**	**2,650**	**240**	
Licensing	350	360	340	(20)	
Pre-Emplacement Construction	500	510	470	(40)	
Emplacement Operations	990	1,010	1,020	10	
Monitoring Operations	450	460	640	180	
Closure & Decommissioning	60	67	180	110	a
Waste Acceptance, Storage & Transportation	**6,390**	**6,490**	**5,630**	**(860)**	
Development & Evaluation (1983-2005) Costs	**530**	**540**	**530**	**(10)**	
Storage (no ISF Facility)	200	210	210	0	
Transportation	240	240	230	(10)	
Waste Acceptance	30	29	31	2	
MPC Project	40	38	38	0	
Project Management and Integration	20	16	16	0	
Mobilization and Acquisition (2005-2010)	**140**	**140**	**110**	**(30)**	
National Transportation	120	120	91	(29)	
Waste Acceptance	10	10	10	0	
Project Management and Integration	10	10	10	0	
Operations (2010-2042)	**5,720**	**5,810**	**4,990**	**(820)**	
National Transportation	5,660	5,750	4,930	(820)	
Waste Acceptance	60	57	57	0	
	0	0	0	0	
Nevada Transportation	**790**	**800**	**790**	**(10)**	
Engineering & Construction	700	710	710	0	
Operations	90	90	80	(10)	
Program Integration	**3,990**	**4,040**	**4,200**	**160**	
Program Management and Administration	**3,330**	**3,380**	**3,500**	**120**	
Quality Assurance	670	680	670	(10)	
Program Management and Integration	2,230	2,260	2,380	120	
Human Resources & Administration	430	440	450	10	
Non-OCRWM NWF Costs	**660**	**660**	**700**	**40**	
Nuclear Regulatory Commission	600	600	630	30	
Nuclear Waste Technical Review Board	50	51	52	1	
Nuclear Waste Negotiator	10	10	10	0	
Institutional Costs	**3,400**	**3,460**	**4,340**	**880**	
Payments Equal-To-Taxes (PETT)	2,280	2,320	3,070	750	a
Benefits	470	480	590	110	
180 (c) Assistance	450	460	460	0	
Financial Assistance	200	200	210	10	
TOTAL CRWMS COST	**43,690**	**44,410**	**56,890**	**12,480**	

[a] Signifies a scope change to the category. Other deltas are due to the changes in the monitoring length, forecasts, and rounding.

B.4 ASSUMPTION DIFFERENCES

The 1999 TSLCC estimate is based on assumptions that differ from those utilized in the 1998 TSLCC (DOE 1998a). Table B-4 provides a summary of differences in assumptions between the 1998 TSLCC estimate and the 1999 TSLCC estimate.

Table B-4. Differences Between the 1998 and 1999 TSLCC Assumptions

TOPIC	1998 TSLCC	1999 TSLCC
SNF Waste Stream		
SNF Discharge Projection	1995 RW-859 Data	1995 RW-859 Data
MGR Receipt Rate	See Table 3, Table 4, Table 5 in 1998 TSLCC Document	See Table 11, Table 12, Table 13 (Same as 1998 TSLCC)
Waste Acceptance		
Total Amount Accepted	86,300 MTHM Commercial SNF 19,657 defense HLW canisters (5,390 SRS; 1,190 INEEL; 12,442 Hanford, WA; 635 Pu HLW SRS) 276 canisters West Valley HLW 71 Argonne National Laboratory (ANL) HLW 2570 MTHM DOE SNF (3,857 canisters, including 300 naval canisters)	86,300 MTHM commercial SNF 19,657 defense HLW canisters (5,390 SRS; 1,190 INEEL; 12,442 Hanford, WA; 635 Pu HLW SRS) 276 canisters WV HLW 71 Argonne National Laboratory (ANL) HLW 2570 MTHM DOE SNF (3,857 canisters, including 300 naval canisters)
Start Fuel Pickup	2010	2010
Last Fuel Pickup	2041	2041
Transportation		
Cask Capacities	Rail 26 PWR/61 BWR, 12 PWR/24 BWR DPCs 24/61, 21/44, 12/24 PWR/BWR LWT 4 PWR/9 BWR, various Special Casks HLW 5 canisters, DOE SNF (1 to 6 canisters)	Rail 24 PWR/68 BWR, 12 PWR/32 BWR DPCs 24/68, 21/44 PWR/BWR LWT 4 PWR/9 BWR, various Special Casks HLW 5 canisters, DOE SNF (1 to 6 canisters)
Transportation Modal Split	11 Reactor Pool Facilities and 2 DOE Storage Sites Ship by Commercial Truck 46 Pool Facilities Ship by SM Rail 43 Pool Facilities Ship by LG Rail	8 Reactor Pool Facilities and 2 DOE Storage Sites Ship by Commercial Truck 46 Pool Facilities Ship by SM Rail 46 Pool Facilities Ship by LG Rail
Cask Life (year) / Annual Utilization (days)	RX Rail 25 / 270 LWT 25 / 300 HLW 40 / 255 DOE SNF 25 / 270	RX Rail 25 / 270 LWT 25 / 300 HLW 40 / 255 DOE SNF 25 / 270
Rail Shipping	General freight for all rail shipments	General freight for all rail shipments

Table B-4. Differences Between the 1998 and 1999 TSLCC Assumptions (Continued)

TOPIC	1998 TSLCC	1999 TSLCC
Travel Speed	Truck 960 miles/day Rail General Freight – ~10 miles/hour	Truck 960 miles/day Rail General Freight – ~10 miles/hour
Monitored Geologic Repository		
Monitoring Phase	From end of emplacement to 100 years after the beginning of emplacement.	Case 1 - From end of emplacement to 50 years after the beginning of emplacement. Case 2 - From end of emplacement to 125 years after the beginning of emplacement.
Closure & Decommissioning Phase	7 years	10 years
Waste Package Capacity	12 PWR/24 BWR 21 PWR/44 BWR 5 HLW including IPWF 5 HLW co-disposed with 1 DOE SNF DOE SNF various	12 PWR South Texas only / 24 BWR 21 PWR/44 BWR (no assembly heat limit) 5 HLW including IPWF 5 HLW co-disposed with 1 DOE SNF DOE SNF various
Emplacement Method	Large in-drift Waste Packages – Point Loaded	Large in-drift Waste Packages – Line Loaded
Cask Maintenance Facility	Limited maintenance Integrated with Repository Facilities; Responsibility of RSCs	Limited maintenance Integrated with Repository Facilities; Responsibility of RSCs
Number of Cask Shipments	From Reactor Rail (Uncanistered fuel) 5,616 From Reactor Rail (DPC) 5,425 From Reactor Truck 3,037 HLW 4,003 DOE SNF 1,252	From Reactor Rail (Uncanistered fuel) 4,804 From Reactor Rail (DPC) 4,012 From Reactor Truck 1,022 HLW 4,003 DOE SNF 1,252
Number of Waste Packages	Large - 5,723 PWR/3,734 BWR (includes 73 MOX) Small - 854 PWR/144 BWR 2,652 HLW including IPWF 1,349 HLW codisposed with DOE SNF 1,250 DOE SNF 15,706 Total	Large – 6,038 PWR/3,752 BWR (includes 73 MOX) Small - 303 PWR / 110 BWR 2,652 HLW including IPWF 1,349 HLW codisposed with DOE SNF 1,250 DOE SNF 15,454 Total